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FOLLOWING  
HUMANITY'S  
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TO LIVING  
**OFF-WORLD**

HOW  
WE'LL  
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FOR GOOD



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Can we do anything about it?

**EARLY HUMAN  
HYBRID DISCOVERY**  
How diversity made us what we are

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The medicine cabinet in your  
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# D850



*David* **I AM RELENTLESS**



## DAVID YARROW INTRODUCES THE NIKON FULL FRAME D850.

To launch the new Nikon D850, master wildlife photographer David Yarrow was given the creative freedom to capture the image of his lifetime, shot on the D850. Thanks to the powerful combination of the 45.7MP FX format back-side illuminated CMOS sensor and the speed of 9\*fps shooting, he could tell a story like never before. With ISO 64 to 25600, 153-point AF, 8K time-lapse\*\* and full frame 4K UHD video, now you too can capture your masterpiece. David is passionate about wildlife conservation, and is the affiliated photographer of the Tusk Trust Foundation. To find out more about the D850, and David's story, visit [www.nikon.co.uk](http://www.nikon.co.uk)

\*Requires the optional MB-D18 Multi-Power Battery Pack, EN-EL18a/b battery, BL-5 battery cover and MH-26a charger.

\*\*Requires Interval Timer settings and 3rd party software.





# WELCOME



“When I first looked back at the Earth, standing on the Moon, I cried.” Those are the words of astronaut Alan Shepard, who in 1971 became the fifth person to walk on the Moon, 10 years after becoming the first American to travel into space. He’s one of the select few who’ve seen Earth as a globe from space – an experience that’s often described by astronauts as giving them a sudden awareness of the fragility of our

planet. Psychologists have dubbed this ‘the overview effect’.

One day, we might all experience this feeling. As temperatures rise, populations grow and ecosystems strain under our influence, the Earth is looking increasingly fragile. Indeed, last year Prof Stephen Hawking warned that we only have 100 years left to find a new home planet.

It might sound like pie in the sky, but the idea of leaving Earth for good is one that scientists are taking seriously. From 3D-printed buildings to asteroid mining, and from space agriculture to food made from poo, a raft of new technologies will make it easier for our descendants to set up base elsewhere in the cosmos. Meanwhile, recent experiments on the International Space Station are revealing more about how we’ll stay healthy on long-term missions, and how space travel affects the human reproductive system – something that’s crucial to understand if we’re ever going to go forth and procreate on another planet. Our special report starts on page 40.

*Daniel Bennett*

Daniel Bennett, Editor

## IN THIS ISSUE



### SIMON CROMPTON

Simon, a former health editor for *The Times* and *The Daily Telegraph*, has been attempting to get to grips with the alarming male suicide rate. → p70



### EMMA DAVIES

With a PhD in food chemistry, Emma was the ideal person to look at the surprising health benefits of one of Britain’s favourite meals: curry. → p63



### COLIN STUART

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## WANT MORE?

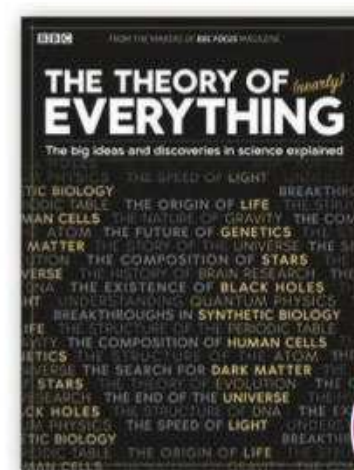
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## SPECIAL ISSUE



**ON SALE NOW**

### THE THEORY OF (NEARLY) EVERYTHING


The latest special edition of *BBC Focus* details the years of research that led us to our current 'best picture' of how the Universe works – from the Big Bang to the hunt for dark matter.

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EYE OPENER

## High in salt

**YUNCHENG**, CHINA

This spectacularly coloured aerial photograph shows the Yuncheng salt lake in the Shanxi province of northern China – otherwise known as the Dead Sea of China.

High temperatures in the region are responsible for the water's brightly hued appearance. As the weather warms up – the average summer temperature is around 27°C – different microorganisms flourish in different parts of the lake, each giving the water its own distinctive shade.

The salt lake at Yuncheng was formed around 500 million years ago, and humans have been harvesting salt there for 4,000 years. Unlike the Dead Sea in Israel, which is heavy in sodium chloride, the salt at Yuncheng is sodium sulphate – it is, in fact, the third biggest sodium sulphate lake in the world.

ALAMY



EYE OPENER

# Shake it off

CALIFORNIA, USA

An Anna's hummingbird is captured on camera shaking off the water from an artificial rain shower. The birds can shake their bodies up to 55 times a second, with each shake generating a force 34 times that of gravity.

There are believed to be around 1.5 million Anna's hummingbirds (*Calypte anna*) living on the USA's Pacific seaboard, and they owe their success partly to humans. Until the early 20th Century they were confined to the southernmost part of California and the Mexican state of Baja California, but flowers and bird-feeders in gardens have allowed them to expand their range considerably, and they can now be found all year round as far north as British Columbia in Canada, and as far east as Arizona.

Others species aren't so lucky. "Habitat loss and destruction are hummingbirds' main threats," says Itala Yopez, head of conservation (Americas) at BirdLife International. "The Earth's changing temperatures due to climate change are affecting hummingbird migratory patterns, causing different species to be spotted in locations well outside their normal range, where it may be harder for them to find food."

ANAND VARMA/NATIONAL GEOGRAPHIC














EYE OPENER

# What floats your boat

**LA ROCHE**, SWITZERLAND

Despite the post-apocalyptic appearance, the boats here are not actually abandoned. Switzerland's Lake of Gruyère is a manmade reservoir that experiences a yearly cycle of fluctuating water levels. Every year during winter and spring, water is released from the lake in preparation for the meltwater of heavy snowfall from the surrounding mountains. In March 2018, the water level was reduced by 15 metres, rendering the boats unusable.

The reservoir was formed by the building of a hydroelectric dam, called the Rossens Dam, to provide electricity to the surrounding villages. It was constructed in 1941 and carries water through an underground pipeline to the Hauterive generating station. Here, the station utilises the hydrostatic pressure produced by the body of water to drive a water turbine and generate electricity. While the water level is low, the island of Ogoz in the centre of the lake becomes accessible by foot, only for the path to be swallowed up by melted snow when summer returns.

SHUTTERSTOCK



# REPLY

Your opinions on science, technology and *BBC Focus*

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## MESSAGE OF THE MONTH

### Multi-tasking mucus

The silvery slime or mucus secreted by slugs and snails (July, p84) has many more advantages, and sometimes disadvantages, than just helping the molluscs to move around easily.

In the marine world, it has been found that some snails add nutrients – particularly nitrogen – to their slime as a fertiliser that stimulates the growth of the algal spores which get stuck to the mucus, thus enriching the habitat for future grazing.

Slime can also be used for navigation, a prime example being limpets, who use their own mucus trails to find their way back to their home spot on the rocks after feeding. They then seal themselves down with mucus to combat desiccation as the tide recedes. Terrestrial snails can also seal themselves into their shells during hot, dry spells.

The slime also contains some pheromones, therefore allowing others of the same species to find a mate (or an aggregation of others for mass mating, as with sea hares and other sea slugs). The creatures seem to be able to sense which direction the trail has been laid in. Unfortunately, though, carnivorous snails can also follow these trails to find their prey, while others can add toxins to ward off predators or secrete toxic mucus which makes them distasteful.

And it's not just other molluscs that have to be wary of mucus trails. Some years ago marine scientists from Plymouth noted that barnacle larvae avoided settling on dog whelk trails, a voracious predator of barnacles, or near to some species of limpets which have a habit of bulldozing the settling barnacles from the surface of rocks.

Paul Biggin, Hertford

#### WRITE IN AND WIN!

The writer of next issue's *Message Of The Month* wins a **Zwitscherbox**. The Zwitscherbox is equipped with motion sensors and will play two minutes of Bavarian birdsong whenever anyone enters the room, which maker Relaxound says is proven to reduce stress and enhance wellbeing.

relaxound.com



WORTH  
£40



Why don't marine animals get the bends? Because they're not using scuba gear, says Henry Depew

#### Dive free

Further to your question, 'Can marine animals get the bends?' (Summer, p82), all marine mammals are freediving, and while carbon dioxide may build up over time, the nitrogen they took with them is all they have as opposed to breathing in scuba diving. Scuba diving and its various forms push nitrogen into the bloodstream, freediving does not. Hence, there's little chance for 'the bends' with freediving.

Henry Depew,  
Tallahassee, Florida

#### The Maltese molar

Your feature on Neanderthals (Summer, p64) is of particular interest to us in Malta. The last Neanderthal to be identified was in

2016, when two leading physical anthropologists, Prof Shara E Bailey and Aida Gomez-Robles, confirmed a molar that was discovered in the Dula Cave in Malta in 1917 as Neanderthal. This find was unique in that the micro-anatomical features on this molar suggested a blend of Neanderthal with anatomically modern humans of the Late Palaeolithic.

Prof Chris Stringer at London's Natural History Museum extended the research on the molar and involved Prof Svante Pääbo in the discovery.

Pääbo, a Swedish biologist, is one of the founders of

palaeogenetics and has worked extensively on the Neanderthal genome. He arranged





for DNA studies of the tooth at the Max Planck Institute for Evolutionary Anthropology in Leipzig, in order to settle the issue of whether humans on Malta had mated with Neanderthals. But at that stage the local archaeological establishment opted to take matters into their own hands, and the outcome is still being awaited.

**Anton Mifsud, MD, DSc, DCH (Lond)**

### Flatly speaking

Your comparison (September, p58) of those who do not believe the official account of (eg) President Kennedy's assassination with Flat Earthers and neo-Nazis discredits you. In the case of the Kennedy assassination, the United States House Select Committee on Assassinations concluded in 1979 – in contrast to the conclusions of the Warren Commission – that Kennedy was “probably assassinated as a result of a conspiracy,” which seems like an understatement of the blindingly obvious. That the cooperation and silence of what seems likely to have been a large number of conspirators could be achieved lends credibility to other, more

**JFK – there was definitely some kind of conspiracy, argues Martin Keating**

recent, alleged cover-ups by the leaders of western democracies.

**Martin Keating, Falkirk**

### Apollo omission

I read your article celebrating 60 years of NASA (August, p56), and am astonished that you left out one of the most important missions NASA ever undertook: Apollo 8.

The Apollo 8 mission achieved a number of significant firsts – the first manned flight of the Saturn V rocket, the first mission to send humans beyond the pull of Earth's gravity – and produced the stunning *Earthrise* photograph taken by astronaut Bill Anders. How could you leave this out?

**Steve Jones, Bedford**

### Oops

On p22 of our September issue, we said that pancreatic cancer patients who received treatment with CBD lived up to three times longer. This was incorrect as the study involved mice rather than human patients.

Apologies, puzzlers. In our September crossword (p96) there were two clues numbered as 21 down.



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# AT THE READY

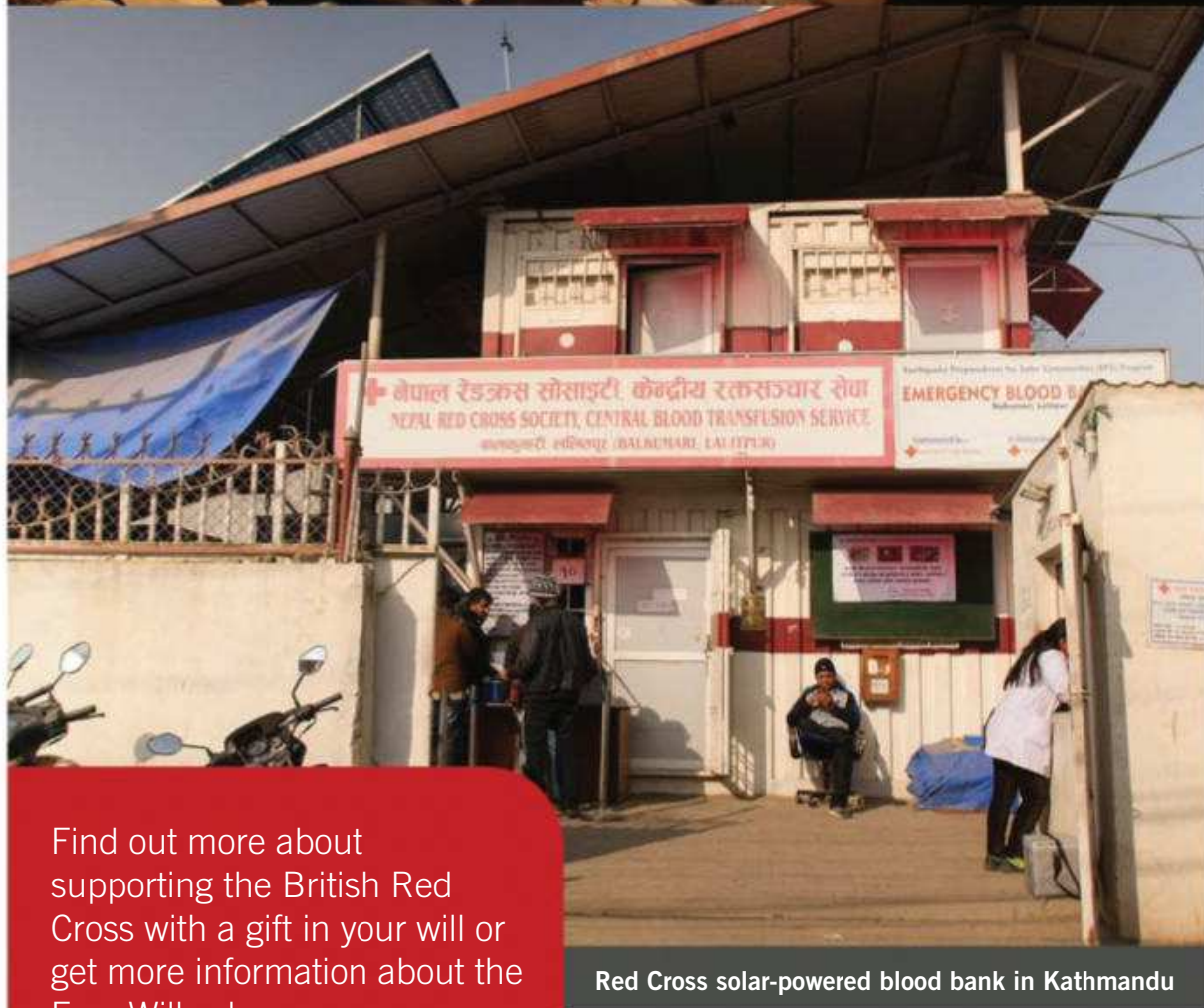
**The British Red Cross is carrying out valuable work in Nepal – even before disaster strikes**

As a humanitarian aid organisation, the British Red Cross is used to responding to communities in crisis. But its groundbreaking work in Nepal is as much focused on helping people prepare for potential disaster as on supporting them in dealing with the aftermath.

Since 2012, the British Red Cross has been working with people in the Kathmandu Valley, providing training on how to minimise risk and take action when an earthquake strikes. When the last one hit in 2015, more than 8,000 staff and volunteers across the affected districts were ready to respond, carrying out search and rescue operations, evacuations and first aid – with 10,000 emergency kits already prepared and ready to distribute.

To ensure Nepal can deal with a major emergency, the British Red Cross, with support from DFID, have also built a solar-powered blood bank in the country's capital. Blood supplies need to be kept chilled so this facility, built from sturdy shipping containers, will ensure reserves are kept cool even if there's an earthquake-induced power cut.

All of this work is only possible thanks to the generosity of supporters. By leaving a gift in your will, you can leave your own legacy and ensure this vital charity can support people in crisis around the world – as well as those who desperately need help right on your own doorstep.



Red Cross solar-powered blood bank in Kathmandu

Find out more about supporting the British Red Cross with a gift in your will or get more information about the Free Will scheme

**call 0300 500 0401 or visit [redcross.org.uk/FreeWill](http://redcross.org.uk/FreeWill)**

 **BritishRedCross**



# DISCOVERIES

DISPATCHES FROM THE CUTTING EDGE

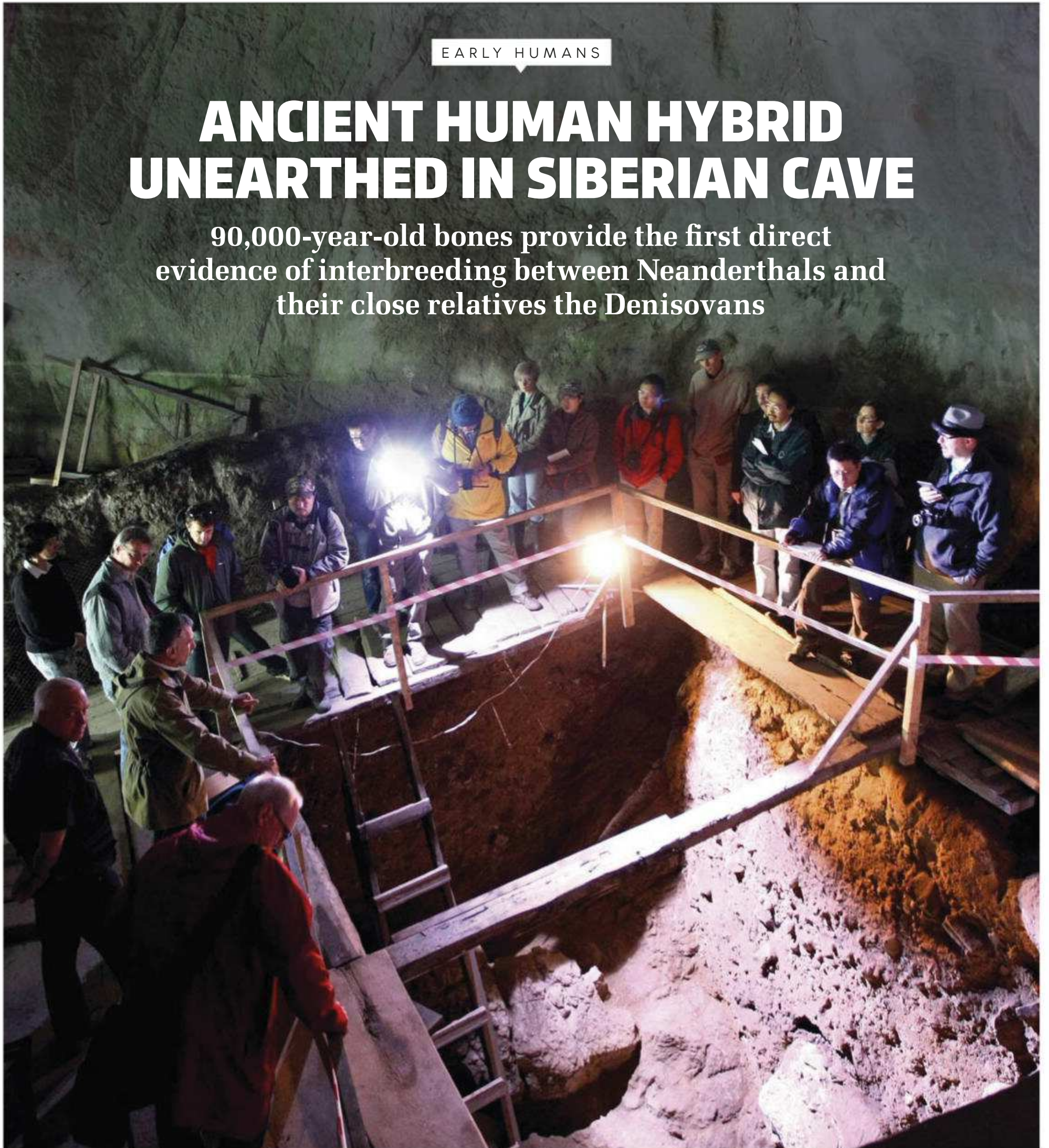
OCTOBER 2018

EDITED BY JASON GOODYER

EARLY HUMANS

## ANCIENT HUMAN HYBRID UNEARTHED IN SIBERIAN CAVE

90,000-year-old bones provide the first direct evidence of interbreeding between Neanderthals and their close relatives the Denisovans





“DENNY IS THE ONLY  
KNOWN EXAMPLE OF A FIRST-  
GENERATION CHILD WITH EQUAL  
PARTS NEANDERTHAL AND  
DENISOVAN DNA”

It seems that the idea of free love started a lot earlier than the 1960s. An international team of researchers has found a tiny bone fragment belonging to an ancient hominin, named ‘Denny’ by the team, that had a Neanderthal for a mother and a Denisovan for a father – two of the closest extinct relatives of currently living humans.

Up until around 40,000 years ago, the two groups are known to have lived on the combined continent of Eurasia – Neanderthals in the west of the continent, Denisovans in the east. Previous genetic studies of ancient hominin remains have shown that they sometimes interbred, but Denny is the only known example of a first-generation child with equal parts Neanderthal and Denisovan DNA.

The bone fragment was found in 2012 at Denisova Cave in Russia and taken to the Max Planck Institute in Leipzig for genetic analysis, after being identified as a hominin bone due to its protein composition. It is thought that the bone is a



ABOVE: The bone fragments unearthed in Siberia in 2012

BELOW: Work at the cave is still ongoing



fragment of the arm or leg of a young female, who would have been aged around 13 when she died some 90,000 years ago.

“It is striking that we find this Neanderthal/Denisovan child among the handful of ancient individuals whose genomes have been sequenced,” said Prof Svante Pääbo at the Max Planck Institute. “Neanderthals and Denisovans may not have had many opportunities to meet. But when they did, they must have mated frequently – much more so than we previously thought.”

Genetic analysis of the bone indicates that the mother was more closely related to the 55,000-year-old Neanderthal remains found in the Vindija Cave in western Europe than those of another, the so-called Altai Neanderthal, that lived in the Denisova Cave at an earlier date. This means that Neanderthals must have at some point travelled between western and eastern Europe.

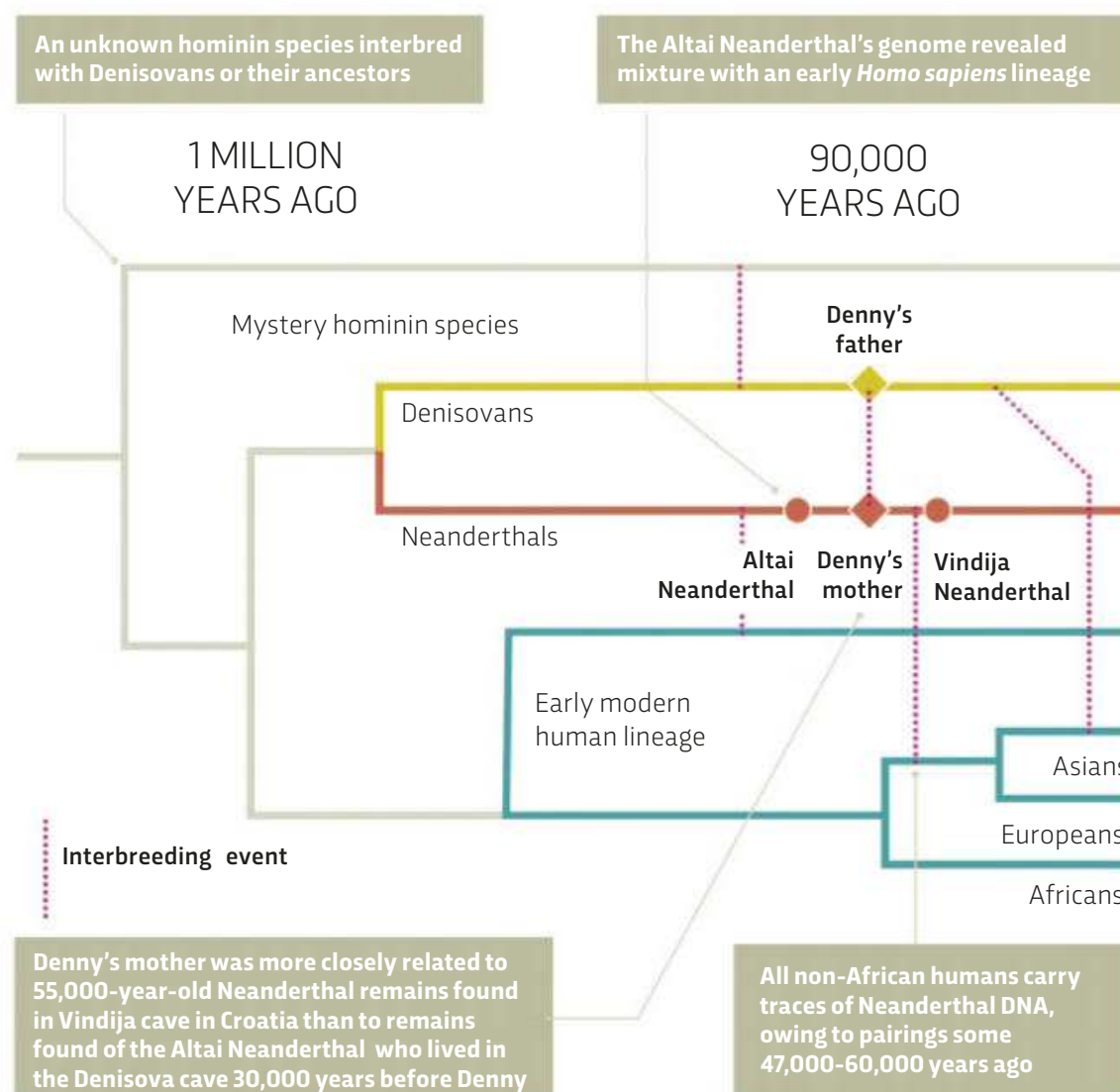
The team also found evidence in the genome that the Denisovan father had at least one Neanderthal ancestor further back in his family tree – between 8,000 and 17,000 years before Denny lived

“An interesting aspect of this genome is that it allows us to learn things about two populations – the Neanderthals from the mother’s side, and the Denisovans from the father’s side,” said Dr Fabrizio Mafessoni, also from the Max Planck Institute.



# Ancient humans: a family tree

Denny, born to a Neanderthal mother and Denisovan father roughly 90,000 years ago, is one of many examples of interbreeding between ancient human groups.



## EXPERT COMMENT

### Rebecca Wragg Sykes

Archaeologist based at the Université de Bordeaux

"It's hard to overstate the importance of finding Denny. A decade ago we had no clue that her father's people even existed, much less that children like her existed. In May 2010 the first Neanderthal genome was published, proving that rather than usurping them, early *Homo sapiens* made babies with them. But just the month before, samples from a tiny finger bone in Denisova Cave, Siberia revealed an entirely new hominin species.

"Now known as D3, this bone was at least 10,000 years younger than Denny. Thanks to ancient DNA, today we've identified five Denisovans. But we know more about their history as a species than we do about their technology or even their appearance. Some of them had genes for dark hair, skin and eyes, but how tall they were or what their faces were like are mysteries.

"Despite all samples so far coming from one site, they were far from isolated. Both they and Neanderthals bred with *H. sapiens*, but in different times and places. Asians and native Americans have more Neanderthal DNA than Europeans, which might reflect more interaction in that region, or elsewhere in a group which later moved eastwards. Denisovan blood is even more unevenly distributed: living populations of Oceania and Australia have up to 25 times more than anywhere else. It's clear we're seeing only a fraction of the true picture.

"Neanderthals and Denisovans weren't shy of each other, either. D3's genes showed interbreeding tens of thousands of years before she died. Denny's father's forebears were also making babies with Neanderthals up to 17,000 years earlier. Intriguingly, those far off encounters were with a Neanderthal lineage different from that of Denny's mother.

"Finding the child of a Neanderthal and a Denisovan should make us sit up and think. Until now, most evidence has pointed to small, localised populations in both species. Added to this, studies mapping the distances that stone tools were moved from their source pointed to relatively limited territories. On this basis, dominant theories emphasised Neanderthals as socially 'exclusive': avoiding outsiders, limited to topographic, cultural and genetic valleys. If that's true, it's unlikely we would ever find the result of such an encounter, so Denny is telling us something about these models is wrong.

"Populations were likely small, so the startling fact of Denny's parentage means the other part of the equation must be wrong: Denisovans and Neanderthals must have been quite keen on strangers. But how did populations who were happy to blend stay so distinct genetically? One theory is that mixed children had a tougher time reproducing, but we just don't know yet.

"Why does this matter? One of the most influential ideas about why the Neanderthals disappeared is that *H. sapiens* had more extensive territories – if we map the distances stone tools were carried, early *H. sapiens* come out ahead. But finding Denny strongly suggests stone tool mobility can't be a real measure of sociability. Another extinction theory may soon bite the dust."



## EXOPLANETS

# MEDIUM-SIZED EXOPLANETS MAY BE MOSTLY MADE OF WATER

Interstellar explorers of the future might want to pack a pair of fins and a snorkel, because a new analysis of data from the Kepler Space Telescope and ESA's Gaia mission suggests that many exoplanets may be mostly made of water.

To date, astronomers have confirmed the existence of 3,815 exoplanets, which can be broken down into five types: 'hot Jupiters'; cold gas giants; water worlds; rocky planets; and lava worlds. Until recently, exoplanets measuring 1.5x or 2.5x the radius of Earth were thought to be rocky planets, while larger exoplanets at least 4x the radius of Earth identified as water worlds. But now, research led by Harvard University's Dr Li Zeng suggests that exoplanets with 2.5x Earth's radius may actually be up to 50 per cent water, compared to Earth's 0.02 per cent.

"Our data indicated that about 35 per cent of all known exoplanets which are bigger than Earth should be water-rich," said Zeng. "This is an exciting time for those interested in those remotes."

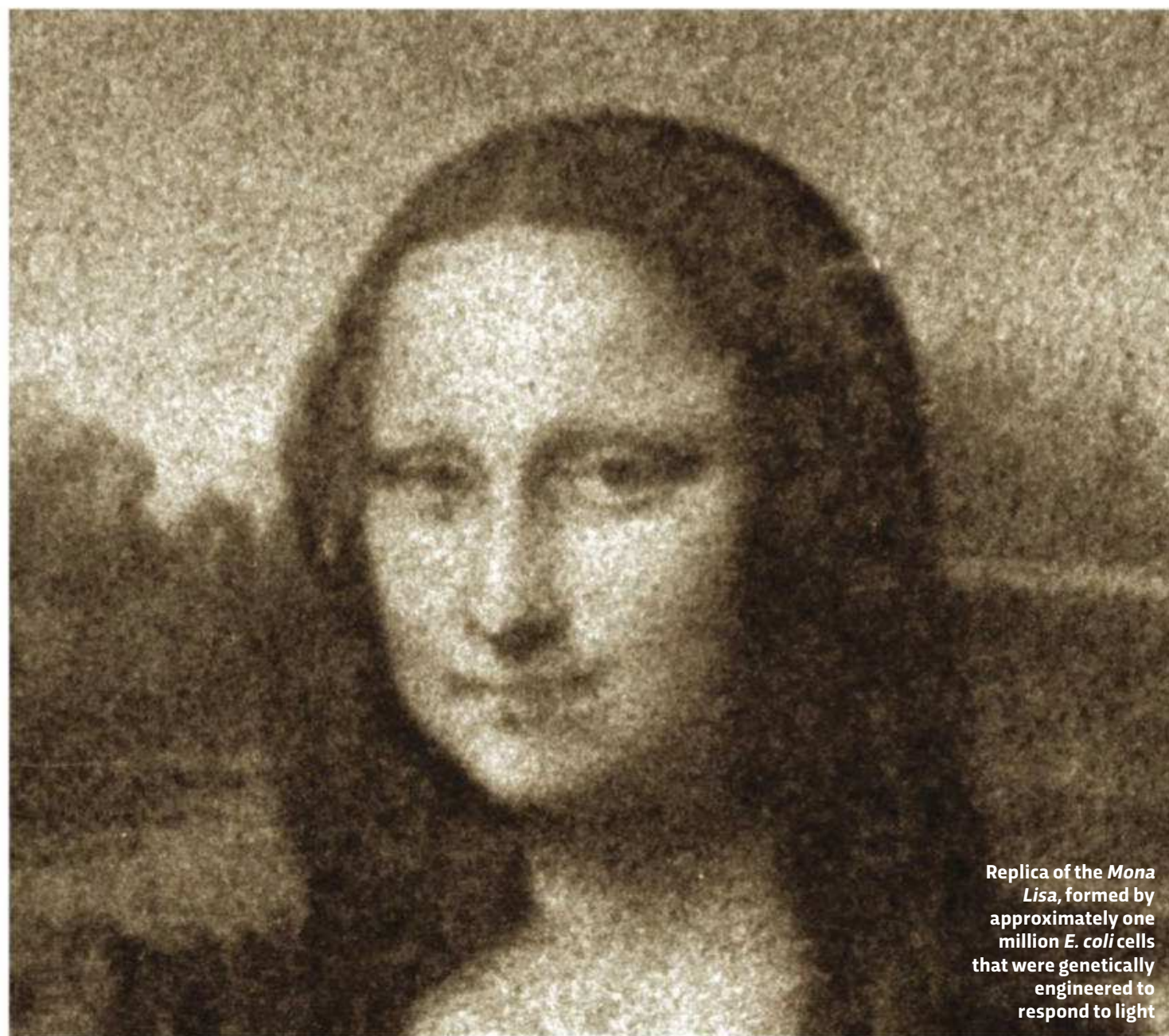
Water worlds can be found in our own Solar System. Beyond Neptune there are several dwarf planets and satellites composed mostly of ice clustered around a rocky core. The composition of exoplanetary water worlds, however, is thought to be somewhat different: they're likely to have atmospheres of steam, with a thin layer of water underneath and surface temperatures of up to 500°C.

It's hoped that NASA's recently launched TESS mission will discover more such planets, and that the James Webb Space Telescope, due to launch in 2021, will reveal more about their composition and atmospheres.

Exoplanets, like those seen in the artist's impressions below, are planets that exist outside of our Solar System







Replica of the *Mona Lisa*, formed by approximately one million *E. coli* cells that were genetically engineered to respond to light

BIOLOGY

## SCIENTISTS PAINT A MINI MONA LISA USING GM BACTERIA

This recreation of the *Mona Lisa* may be a little blurry, but it's still the best effort at reproducing a masterpiece using genetically modified bacteria that we've ever seen.

The picture was made by Italian scientists at the Sapienza University of Rome. Rather than trying to pull off some kind of germ-based art fraud, the researchers were investigating methods for making large populations of bacteria move around on command. To do this, the team modified the DNA of *E. coli* bacteria so they would produce the protein proteorhodopsin in their tiny flagella – the 'tails' which the bacteria use to move around. Proteorhodopsin is light-sensitive, and is used in some microorganisms to generate energy.

"Much like pedestrians who slow when they encounter a crowd, or cars that are stuck in traffic, swimming bacteria will spend more

time in slower regions than in faster ones," said lead author Dr Giacomo Frangipane. "We wanted to exploit this phenomenon to see if we could shape the concentration of bacteria using light."

The proteorhodopsin in the bacteria's flagella meant they could be made to move either faster or slower, depending on how much light they were exposed to. Slower-moving bacteria would clump together (to form dark areas in the picture), while faster-moving bacteria spread further apart (to create lighter areas in the picture).

The researchers hope that by learning how to control bacterial movement, we may eventually be able to create microscopic 'machines' to deliver drugs within the body. The technique could also have applications in 3D printing.

### IN NUMBERS

# 30

The number of remaining South African coelacanths, a fish species that is 420 million years old. The fish, which pre-date dinosaurs, are now under threat from proposed oil drilling close to their habitat.

# 6.5

The percentage of adults over the age of 40 who experience 'phantom odour perception' – smelling things that aren't there – according to the first large-scale US study of the phenomenon. Its causes are not yet understood.

# 3,300

The age in years of the oldest cheese ever discovered.

It was unearthed in an Egyptian tomb in 2013, but has only just been identified. It was made of goat, sheep and buffalo milk – and contained the *Brucella melitensis* bacteria, which can cause a nasty infection.



## HEALTH

# "There were increases in beneficial bacteria in people who consumed crickets"

*According to a new clinical trial, eating insects is good for your gut. Dr Tiffany Weir of Colorado State University explains how it affects microbes*

ABOVE: Insects don't have to be eaten whole – they can be ground up into powder and added to other foods, which may make them more palatable to Westerners who struggle to see past the 'ick' factor

## What are the benefits of eating insects?

Insects are more nutrient-dense than a lot of the other protein sources we consume: on a per-weight basis, they have more protein and fibre than many meat products. If cultivated in the right way, they can be far more environmentally sustainable [than meat]. Outside of the US and Europe, insect consumption is common: they are regularly eaten by about two billion people.

## Why are gut microbes useful to humans?

Each of our bodies contains trillions of microorganisms. The majority of these reside in our gastrointestinal tract and, within any given individual, there are hundreds of species carrying out all kinds of activities. Collectively, all those microorganisms are termed the 'microbiome' – it's not just bacteria, it's viruses and fungi as well. My colleague Valerie Stull has been studying insect consumption, and my area of interest is the influence of diet on the gut microbiota. We wanted to see if there were any benefits to consuming insects beyond their nutritive value.

## How did you study insect consumption?

We had 20 people in the trial, and we asked them

to replace their breakfast every day with muffins and chocolate malt milkshakes that either contained or didn't contain cricket powder. They were eating those meals for two weeks, had a two-week rest period where they went back to their normal diets, and then they switched groups and ate the other meals for two weeks. We collected stool and blood samples to look at the outcomes.

## So how did the crickets affect the body?

There were increases in what would be considered certain beneficial bacteria and a reduction in inflammation in the bodies of people who consumed crickets. We saw an increase in *Bifidobacterium*, one of the first microorganisms that colonises the gut of babies. It helps infants gain more nutrients from their diets, aids with development of the immune system, and protects them from pathogen infections. We maintain those bacteria throughout our life but they tend to decrease as we age, so they're commonly sold as probiotic supplements or are added to certain types of foods, like yoghurt. We also saw a reduction in 'TNF-alpha', a common inflammatory marker. Small amounts of acute inflammation are necessary for fighting off infections, but high





### GENERATION INKED

A study at the University of Miami and the University of Western Australia has found that tattooed job candidates now face minimal negative preconceptions from employers, and suffer no wage disadvantage compared to non-tattooed peers.

### WILD CATS

Plans to reintroduce wild lynx to Northumberland's Kielder Forest look likely to go ahead after 20 landowners declared their support for the scheme. A decision from Natural England, which manages the forest, is expected soon.

**GOOD MONTH**

**BAD MONTH**

### SQUABBLING SPOUSES

Married couples who often get into rows could be making themselves ill. Researchers at Ohio State University found that bickering couples are more likely to suffer from leaky guts – a condition that releases bacteria into the blood and can lead to health conditions such as chronic fatigue syndrome and multiple sclerosis. It is thought to be due to the stress associated with arguing

### SMUTTY COMEDIANS

Well £\$\*% me! Men who tell dirty jokes on first dates are deemed to be less attractive partners when it comes to both short-term and long-term relationships, a study carried out at the University of Southern Mississippi has found.



BELOW: Crickets, peanuts and lemons for sale at a market in Puebla, Mexico

levels – often a side effect of consuming a Western diet – can lead to conditions like diabetes and cardiovascular disease. Reducing inflammation can benefit long-term health outcomes. We were working in a population of young, healthy adults, so we might see greater benefits in a population that's at risk of chronic diseases of the gut.



### DIGESTED READ

People around the world eat insects, yet in Europe and the US, creepy-crawlies do not comprise a major part of the diet. Nonetheless, there has been increasing interest in eating them, as they are packed with protein and require few resources. As well as being full of nutrients, they may also encourage the growth of beneficial bacteria in our guts.

**What's next?**  
We think the benefits are at least partially due to a type of fibre found in insects called 'chitin'. The only other things in our diet that have chitin are mushrooms and the shells of crustaceans like crabs and prawns, but we typically don't eat the latter. We think that chitin might be enhancing the growth of the beneficial bacteria. It's a really small study so it needs to be repeated with more people, but it's a promising start.





## ZOOLOGY

# BELUGA WHALES AND NARWHALS GO THROUGH MENOPAUSE

Menopause is rare in the animal kingdom. While many species may be less likely to reproduce as they near the end of their life, until now only three animals were known to have an 'evolved strategy' where females have a significant post-reproductive lifespan: humans, killer whales and short-finned pilot whales. But now researchers at the University of Exeter and the University of York have added two more toothed whale species to that list: belugas and narwhals.

The team studied dead whales from 16 species and found dormant ovaries in older beluga and narwhal females, indicating that they had gone through the menopause. The finding suggests that these species are likely to have social structures that involve female beluga whales and narwhals living among a greater number of close relatives as they age.

"For menopause to make sense in evolutionary terms, a species needs both a reason to stop reproducing and a reason to live

on afterwards," said Dr Sam Ellis, of the University of Exeter. "In killer whales, the reason to stop [reproducing] comes because both male and female offspring stay with their mothers for life, so as a female ages her group contains more of her children and grandchildren. This increasing relatedness means that, if she keeps having young, they're competing with her own direct descendants for resources such as food. The reason to continue living is that older females can be of great benefit to their offspring and grand-offspring. For example, their knowledge of where to find food helps the group as a whole survive."

Studies of ancestral human remains suggests they had similar social structures, which may explain why menopause has evolved in our own species, the researchers say. "Looking at other species like these toothed whales can help us establish how this unusual reproductive strategy has evolved," said Prof Darren Croft, also of the University of Exeter.

Beluga whales live in Arctic waters, as do their close relatives the narwhals



## MENTAL HEALTH

## THEY DID WHAT?!

## SCIENTISTS GET THE OUIJA BOARD OUT

## What did they do?

A team of cognitive scientists from Denmark's Aarhus University and University of Southern Denmark, and Germany's Bielefeld University, attended a conference for Ouija board users and invited participants, in pairs, to take part in a 'séance'.

## Why did they do that?

Previous research has shown that when a Ouija board is used, one or more individuals is physically causing the 'planchette' (or more commonly, glass) to move – but that those individuals are often unaware they are doing so. The team wanted to use eye-tracking equipment to find out what's going on.

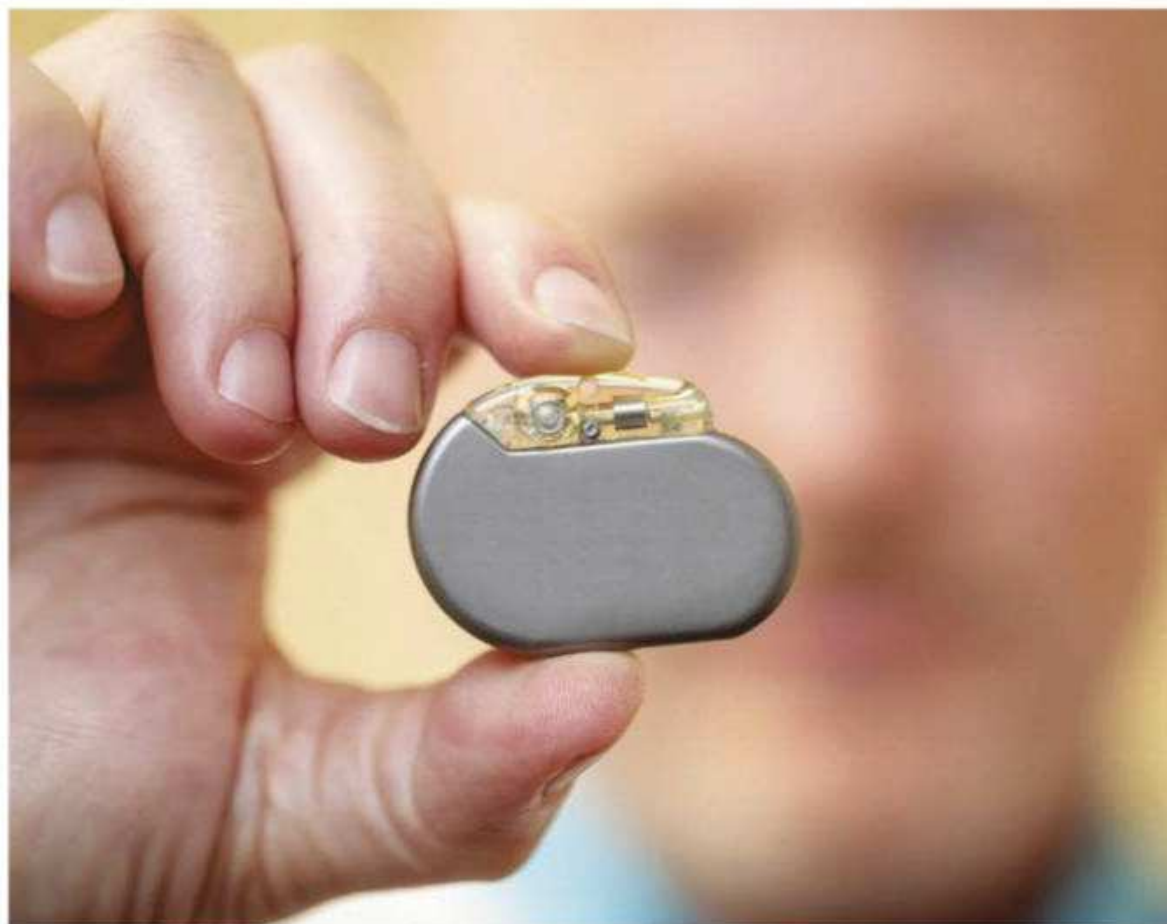
## What did they find out?

When subjects were asked to deliberately spell out a given word, tracking either individual's eye movements would predict the next letter accurately. In a so-called 'séance', no one individual's eye movements could predict what the next letter would be – but combining those of both subjects could. It is believed words are therefore spelled out as the result of a subconscious joint effort.



GETTY, MATT MILLER/WASHINGTON UNIVERSITY SCHOOL OF MEDICINE ILLUSTRATION: LAURENT HRYBYK

## NERVE STIMULATION TREATMENT OFFERS HOPE FOR THE DEPRESSED



This device stimulates the vagus nerve with a tiny electric current. It can help people whose depression is resistant to medication, boosting powers of concentration enough for them to lead a normal life

Up to two-thirds of people suffering from depression don't respond to medication. Now, researchers at Washington University have found that implanting a device that sends mild electrical signals to the brain from the vagus nerve – a nerve that stretches from the brain to the chest – can improve their quality of life.

The study involved nearly 600 patients with depression, whose symptoms could not be alleviated by four or more antidepressants. The team implanted 328 of these with vagus nerve stimulators, while 271 continued with other treatments. They found that those with the stimulators improved markedly in 10 out of 14 quality of life measures including physical health, family relationships and ability to work.

"When evaluating patients with treatment-resistant depression, we

need to focus more on their overall wellbeing," said psychiatrist Prof Charles R Conway, who led the research. "A lot of patients are on as many as three, four or five antidepressant medications, and they're just barely getting by. But when you add a vagus nerve stimulator, it really can make a big difference in people's lives."

Study participant Charles Donovan had been hospitalised for depression several times. "Slowly but surely, my mood brightened. I went from being basically catatonic to feeling little or no depression," he said. "Before the stimulator, I didn't want to leave the house, I couldn't concentrate to sit and watch a movie. But after I got the stimulator, I could do things like read a book or watch a TV show. Those things improved my quality of life."



# TRENDING

Your guide to the hottest topics in the world right now

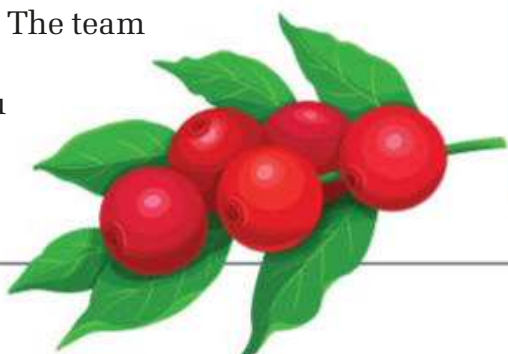
## #PLASTICS

Flushing contact lenses down the toilet could be contributing to the growing problem of microplastic pollution in the world's oceans, say researchers at Arizona State University. They estimate that up to 10 tonnes of plastic lenses make it into wastewater annually in the US alone. Once in the water, the lenses break down to form microplastics that can end up being consumed by marine animals.



## #OBESITY

Camu camu berries from the Amazon could help weight loss, a study at Canada's Laval University has found. Mice fed on a high-sugar, high-fat diet gained 50 per cent less weight when given the berries. Mice eating the berries experienced a boost in the amount of the bacteria *Akkermansia muciniphila* in their guts, and transplanting this into the guts of other mice produced a similar slimming effect. The team now plans to investigate camu camu's effects in humans.



## #AIR POLLUTION

### BREATHE EASY?

Air pollution can shorten human life by more than a year, a study at the University of Texas has found. The team used health data from 185 countries, taken from the Global Burden of Disease Study, to estimate the effect of exposure to particulate matter smaller than 2.5 microns. These fine particles can enter deep into the lungs and increase the risk of heart attacks, strokes, respiratory diseases and cancer.

### DUMBING DOWN

As well as negatively affecting our health, it seems air pollution could also be making us less intelligent. Researchers at Peking University have found that those exposed to higher levels of air pollution performed substantially worse in verbal and numerical tests than those living in areas with cleaner air. Though there is a clear correlation between the two phenomena, the study doesn't prove that there is a definitive causal link between them.



# #AGEING

## WORKING TO DEATH

Taking a holiday could prolong your life, a 40-year study carried out at the University of Finland has found. The study followed over 1,200 middle-aged male executives starting in 1974. They found that those who took less than three weeks' holiday a year had a 37 per cent greater chance of dying over the duration of the study than those who took more.

## OLD ON THE INSIDE

A study at the University of Texas evaluating more than 60,000 brain scans has determined that schizophrenia, cannabis abuse, bipolar disorder, ADHD and alcohol abuse are all associated with increased brain ageing. It is the largest study of brain images ever carried out.



# #SLEEP

Getting less than six or more than eight hours of shut-eye per night could lead to hardening and narrowing of the arteries, researchers from Madrid have found. The study tracked the sleep patterns of nearly 4,000 healthy middle-aged adults using waistband activity monitors, and then assessed the degree of atherosclerosis, or hardening of the arteries, in their necks and legs. Very short sleepers had significantly higher degrees of hardening while very long sleepers had more sections affected by hardening.





## COMMENT

# ARE PROCESSED FOODS MAKING US OBESE?



*Why are Britons getting fatter? A recent article in The Guardian blamed sugar-laden processed foods, but is it really that simple? We asked UCL diet expert Dr Sarah Jackson...*

**T**here's been much talk in the media lately about processed foods and the perils of eating too much sugar, with some suggesting this is the cause of the current obesity crisis. The desire to identify the cause of weight gain is not a new one – in the 80s it was dietary fat that got all the blame. But in reality, the causes of weight gain are many and complex.

Obesity rates have risen sharply in recent decades, for which many blame the 'obesogenic' environment we live in. Processed foods – high in calories which tend to come mostly from sugar – are cheap and widely available, and there's less need to be physically active, due to the automation of many jobs and the rise of screen-based entertainment. However, if that were the case, wouldn't we all be overweight?

What's actually happened, though, is that the distribution of body weight has shifted. People have become heavier overall, but the change is greatest at the upper end: a much larger proportion of people now have 'morbid' obesity – a very high body mass index (BMI) that comes with a host of associated health problems. This suggests that if an obesogenic

environment does exist, its main effect is to make people who were already predisposed to obesity become disproportionately heavier.

In 2007, the late Prof Jane Wardle proposed a behavioural susceptibility theory of obesity to explain how genetic and environmental factors interact and cause people to gain weight. She believed that genetically predetermined differences in appetite could play a key role in determining who gains weight. Individuals whose genes make them highly responsive to food cues are more likely to overeat when palatable food is readily available, and so will tend to eat more often. Those whose genes make them less responsive to feelings of 'satiety' or fullness are more likely to overeat in response to larger portion sizes, and so will tend to eat larger meals. These differences begin to have an effect on

weight very early in life.

The differences in average food intake between people who are overweight and those who aren't are quite small (less than 70 calories a day, according to some studies – about the same as a digestive biscuit), but just a small number of extra calories each day adds up over months and years. So rather than trying to

pinpoint a single cause of obesity or identify a quick fix such as cutting out sugar, people may find it more useful to think more broadly about how they respond to food, and identify strategies to help take control of their eating.

Dr Sarah Jackson is a senior research associate in the Department of Behavioural Science and Health at University College London.



**“A much larger proportion of people now have ‘morbid’ obesity – a very high body mass index (BMI) that comes with a host of associated health problems”**



# DEFYING EXPECTATIONS

VARIETY, INTRIGUE AND THE THRILL OF BEING ON THE CUTTING EDGE ARE JUST SOME OF THE BENEFITS OF A CAREER IN STEM, SAY FOUR WOMEN WORKING AT SCIENCE AND TECHNOLOGY COMPANY JOHNSON MATTHEY

**T**his year marks 100 years since British multinational company Johnson Matthey recruited its first R&D scientist, and today it is still just as committed to supporting the next generation of budding scientists. A leader in its field for more than 200 years, Johnson Matthey uses science to solve complex problems for its customers, and applies unrivalled scientific expertise to enable cleaner air, improved health and the more efficient use of the Earth's natural resources.

***"WE SHOULD BE ENCOURAGING GIRLS TO TAKE UP STEM SUBJECTS, AND THAT SHOULD THEN TRANSLATE INTO INDUSTRY."***

A key part of supporting scientists is addressing the long-term lack of women in STEM. Jen Bhantoo, who worked in product development at Johnson Matthey for six years before becoming a technical sales executive for the company, says: "The preconception that STEM is very male-dominated is changing but we still need to dispel that myth, especially at school level. We should be encouraging girls to take up STEM subjects, and that should then translate into industry." Johnson Matthey invites schools to visit the company, where students can speak to staff about their jobs and experiences, and is keen to get more women into careers in science. "Johnson Matthey is very supportive of women in STEM and has a really good representation of them," says Amy Kolpin, a senior scientist at the company. "My experience here has always been very positive."

Communicating the unique advantages of a career in STEM plays an important role in making girls feel confident and enthusiastic about pursuing science. All four scientists stressed that it's far from just white coats and laboratories. "I like that my role isn't constant – it's always evolving and leading to exciting new areas of science," says Tugce Erdan, a principal scientist working in advanced characterisation. "Johnson Matthey is very open to new ideas and always encourages people to follow and catch up with the science scenes around the world."

Sheena Hindocha, who works for Johnson Matthey's new product introduction group, believes that working in STEM offers things you can't get in other jobs. "The skills you learn throughout your life as a scientist or an engineer

and the way you look at the world are slightly different to the norm, and that opens up so many opportunities to you," she says. "The only way we're going to solve some of the challenges the world is facing at the moment, like global warming, is through technology we haven't yet discovered or created. It's a really exciting time to be starting a scientific career."

**TO FIND OUT MORE GO TO  
MATTHEY.COM**

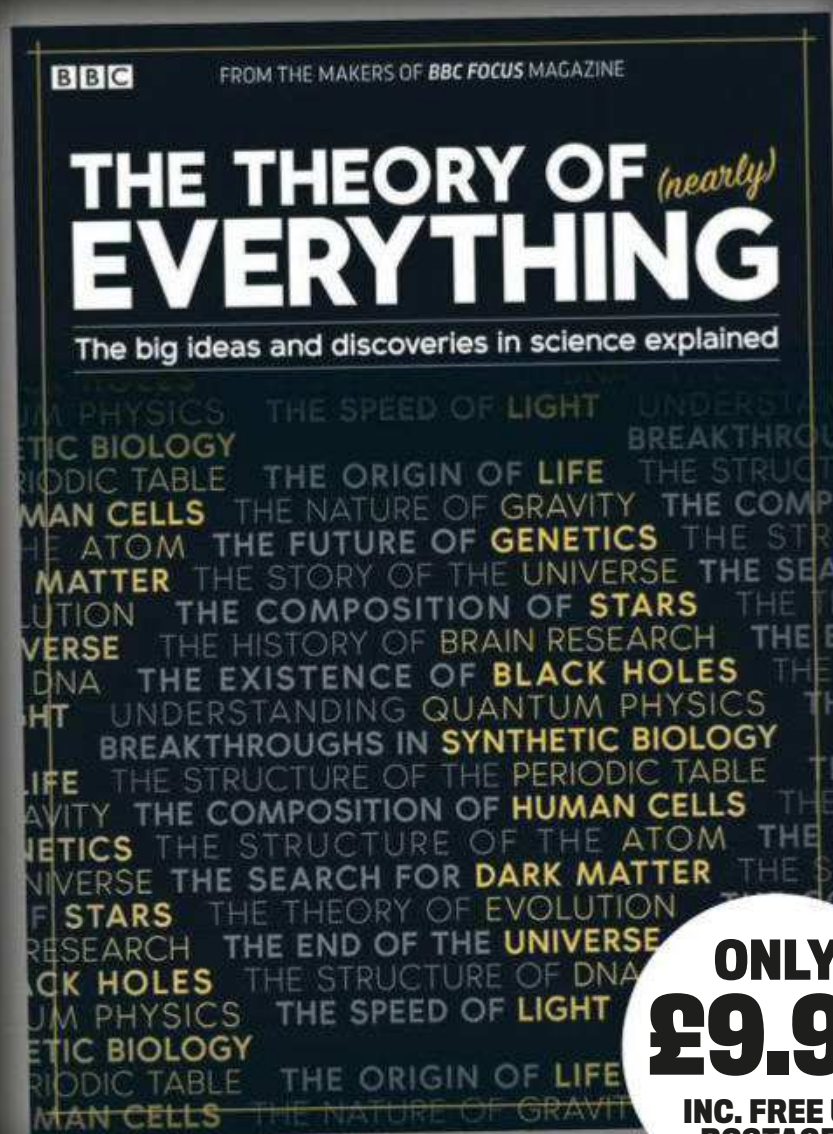
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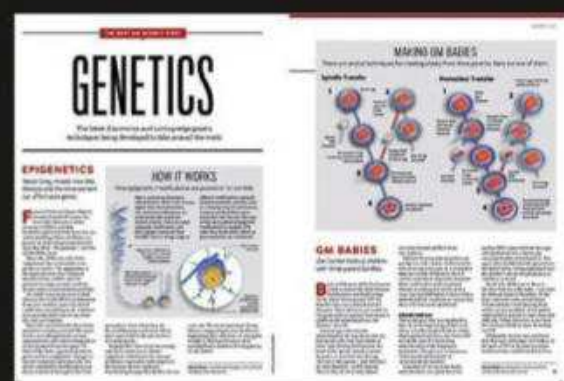
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# SOCIAL MEDIA KILLS SELF-ESTEEM



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**Aleks Krotoski** is a social psychologist, broadcaster and journalist. She presents BBC Radio 4's *Digital Human*.

**B**ack in about 1999, I watched a programme about women's body hair. The premise was simple: take four women – two with a typical Western relationship with body hair and two with extreme body hair phobias – and ask them to stop shaving/plucking/waxing/bleaching for three weeks. The four women fell apart, just because they couldn't use a razor.

This really got up my nose, and not because the scent of passionate, idealistic feminism was still clinging to me like stale patchouli after years at an ardently liberal undergraduate university. No, I was annoyed because I am irritated by most coverage of women's bodies in the mass media. I'm at peak pop culture despair right now because we've just been bombarded with yet another season of the size zero debate, courtesy of London Fashion Week. This is not a new debate, but things have changed since I glared at the telly in my shared Glasgow flat in 1999. Back then, people compared themselves to individuals seen on TV or in magazines. Now, if we use social media, we operate in a world in which we're overwhelmed by the better versions of ourselves that we project into the digital realm. In extreme cases, people decorate their bedrooms to look good on Instagram, or get 'selfie surgery'.

For the women in the body hair experiment, their biggest concern was what their partners would say. Now, the worry is what random strangers will think. The aim in a hyper-visual culture is to get as many likes as possible, and so people will put themselves in front of huge potential audiences. They don't do it to get negative feedback, and so end up conforming even more to gender stereotypes and certain ideas about how people should look.

A study published in *Computers In Human Behavior* in May 2018 surveyed 523 youngsters aged between 11 and 16 about how much they used highly visual social media. Those who spent more than two hours per day online had more body image problems than those who didn't log on

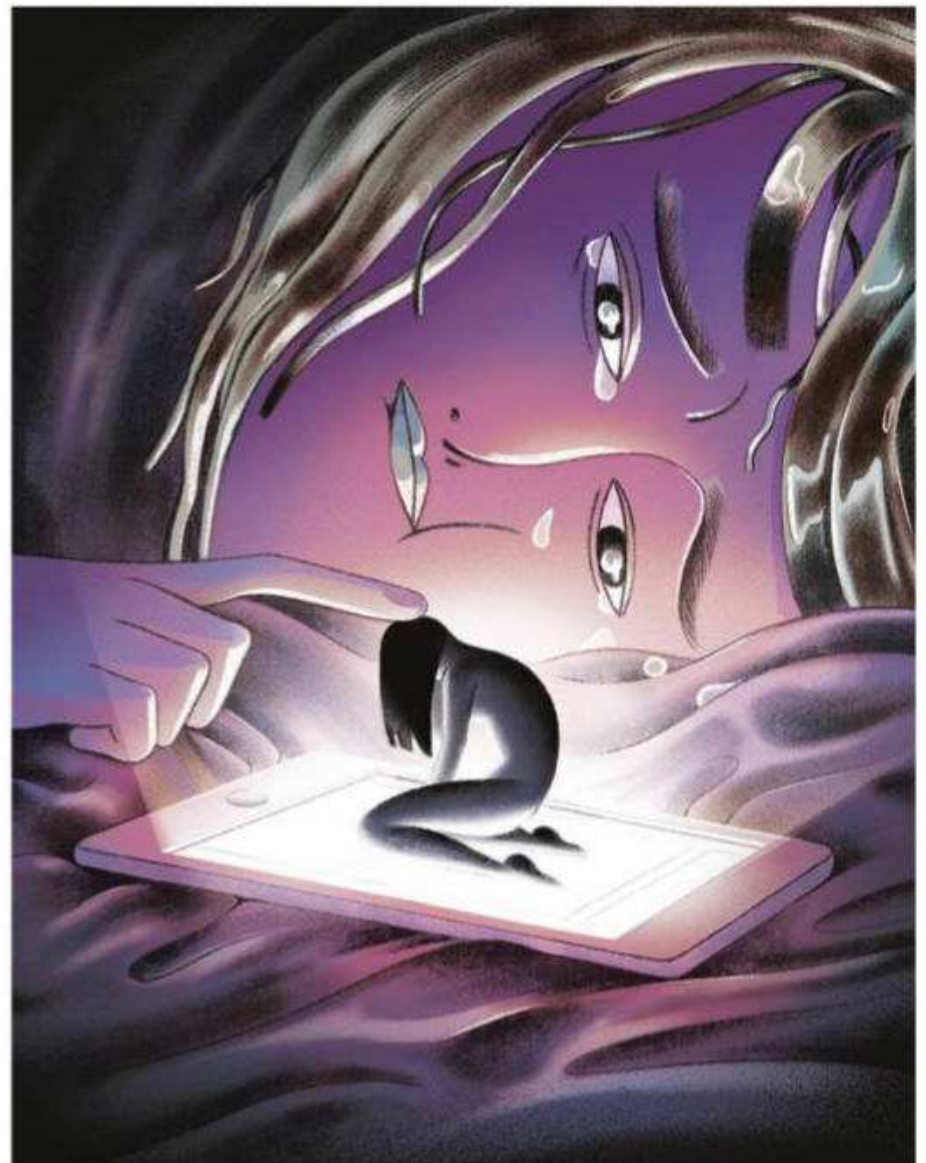
for as long. They could, of course, be turning to social media because they already have body image concerns, but the things they see there reinforce a particular kind of beauty, and that doesn't help them adjust to their personal fears. And even if that particular kind of beauty is clearly retouched or Photoshopped, it's those images that become a source of comparison.

This isn't just a teenage thing, either. In June this year, a study of people aged 17 to 30 published in *Sex Roles* found that looking at images of really fit people posing in a really fit way, and doing really fit things (just search for #fitspo or #fitspiration to see what I'm talking about) made their participants feel bad about themselves and put them in a rotten mood. So don't do it. Looking at people doing fitness isn't aspirational; it just makes you miserable.

Body positive people use the same platform as the #fitspo folks to celebrate our lumpy, many coloured differences. But it turns out that this isn't a solution. I've had a long-standing discussion with my husband about the merits of Gok Wan's series *How To Look Good Naked*. I've described it as empowering and a great step in focusing on the beauty inside. My husband has been more dismissive. And now, I'm beginning to agree: it seems that any attention we pay to body image makes us aware of what we have and have not, and makes the body the fulcrum of our self-esteem. What if, instead, we found out what we're really good at? What if we celebrated what gets us up in the morning?

Perhaps then, we'll be able to relieve ourselves of all that body loathing. Hairy, or not. **F**

**“THEY END UP  
CONFORMING  
EVEN MORE  
TO GENDER  
STEREOTYPES”**



PORTRAIT: KATE COPELAND ILLUSTRATION: REBECCA DUNLAP



# IS VAPING BAD FOR YOUR HEALTH?



**Michael Mosley** is a science writer and broadcaster, who presents *Trust Me, I'm A Doctor* on BBC Two. His latest book is *The Clever Guts Diet* (£8.99, Short Books).

**O**ne of the most encouraging statistics I've seen recently has been the fall in smoking rates, down to an all-time low of 14.9 per cent of the population. There are many reasons for this, but among the most significant has been the rise in vaping. Vaping has taken off thanks to an approach by the UK government which has kept taxes low and allowed a market in vaping devices to flourish. There are rumours that taxes on vaping could be increased in the autumn. Health-wise, that could prove unfortunate.

I first came across e-cigarettes when I was asked to make a programme for *Horizon*. As part of the documentary, I took up heavy vaping. I have never smoked anything before and I wanted to see what effects inhaling nicotine in the form of an e-cig would have on a non-smoker. Fans of e-cigarettes say vaping makes it easier for smokers to quit by providing a safer way to get a nicotine hit. Critics say we are gambling with a technology we don't understand and that it may encourage non-smokers to start. So, who's right? A study for Public Health England concluded that e-cigarettes are 95 per cent less harmful than normal cigarettes. The report also found that increasing numbers of people think e-cigarettes are as harmful, or perhaps more harmful, than smoking.

Why are people worried? Perhaps because of a spate of fear-inducing newspaper stories, such as a US study which inspired this headline: "Electronic cigarettes induce DNA strand breaks and cell death". In the study, researchers took human cells and exposed them to e-cig vapour for a couple of months. They found that some of the cells showed signs of DNA damage, the sort that can "set the stage for cancer". Scary stuff. The lead researcher was quoted as saying that e-cigarettes, "are no better than smoking regular cigarettes".

What the researchers didn't make clear was that they'd also exposed similar human cells to tobacco smoke. All

**"GLOBALLY, A BILLION PEOPLE SPEND AROUND £500BN A YEAR ON CIGARETTES"**



the cells exposed to tobacco smoke died within 24 hours. Which, to me, looks like pretty compelling evidence that e-cigarette vapour is far less harmful.

When I took up vaping, I was concerned about was getting hooked on nicotine. Yet as I puffed away, nothing happened. When I leapt out of bed I didn't feel a longing to reach for my machine. After chatting to experts, I discovered that although cigarettes are highly addictive, nicotine alone may not be. No one knows for sure why this is, but research in animals suggests that nicotine is more addictive when delivered with the other chemicals found in regular cigarettes. But even so, the main justification for e-cigarettes is that they can help those who are keen to quit smoking tobacco, quit. So do they?

There have been few randomised controlled trials, but when *Horizon* conducted a small study where we randomly allocated a group of hardcore smokers to either e-cigs, nicotine patches or going cold turkey, we found the vapers and those who slapped on the patches were far more successful at abandoning their fags.

E-cigarettes are not risk-free. After a month of heavy vaping there were signs of inflammation in my lungs (which rapidly reversed when I stopped), so I would never encourage non-smokers to take it up. But look at the alternative. Globally, a billion people spend around £500bn a year on cigarettes, and half of them will die of smoking-related diseases. In the UK, smoking kills around 78,000 a year, a quarter of all deaths. Anything which gets people off cigarettes is going to save a lot of lives. **F**



# No home, no food and no medical care. Who will help them?

There is no escape for families in Yemen who are fleeing their homes because of war. Millions of children have nothing – no home, no clean water, no food, and no hospital to go to when they are ill or injured.

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# INNOVATIONS

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OCTOBER 2018

EDITED BY HELEN GLENNY

## FASHIONED FROM SCIENCE

In 2004, Andre Geim and Konstantin Novoselov used sticky tape to shave graphite down to a one-atom-thick sample, called graphene. It's the lightest, strongest and most conductive material ever discovered. It's difficult to work with and expensive to produce, but that hasn't stopped high-tech sportswear company Vollebak from turning it into a jacket.

One side of this reversible jacket is coated with gunmetal grey graphene, and the other is matt black nylon. It's a wearable science experiment: depending on how you wear it, the jacket will interact with your body and the environment in different ways – test on one side, control on the other. And the designers want to know what you find out.

Vollebak says that if you wear the jacket in the sunshine with the graphene side facing out, it'll absorb huge amounts of heat, which you can then wear against your body to keep you warm.

The jacket will set you back £525 and is only available in men's sizes, but if you're interested in turning your wardrobe into one big science experiment, then wearable graphene is a great place to start.

**Vollebak Graphene Jacket**

**£525, [vollebak.com](http://vollebak.com)**

Who'd have thought the 'miracle material' graphene would end up in an anorak?





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**2** **THIN TECH**  
At just 1.6kg, Lenovo’s new business laptop is thinner than the MacBook Air and nearly as light, but boasts seriously impressive specs. Made for work travel, the ThinkPad P1 will slip easily into your carry-on bag.  
*ThinkPad P1*  
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£55, [logitech.com](http://logitech.com)

**5** **RIDEABLE ROBOT**  
The Loomo can be ridden like a Segway, but it’ll also talk to you, follow you and carry your shopping. If you think of a new skill that Loomo doesn’t have yet, do it yourself using the Android software development kit.  
*Segway Loomo*  
\$1,299 (approx £1,020), [segway.com](http://segway.com)

**6** **FRESH FEET**  
Panasonic’s new shoe deodoriser generates hydroxyl radicals to destroy the malodorous microparticles that make your footwear fetid. But set some time aside – stubborn odours take up to seven hours to remove.  
*Panasonic Shoe Deodoriser*  
£TBC, [panasonic.com](http://panasonic.com)



## QUITE A CHARACTER

Your robot sidekick's here, and his name's Vector. He'll answer questions, play games, and show you the weather. In other words, nothing groundbreaking. He can't vacuum your floors, chop your vegetables or bring you a beer.

But Vector isn't about functionality, he's about personality. Though he looks like a tiny toy digger, he's been cleverly anthropomorphised (think *WALL-E* or the Pixar desk lamp). He has expressive green eyes and will purr if you pat him. Like any smart speaker, you can activate him with a hot word, like 'Hey Vector', but unlike your Amazon Echo, he'll turn to face you, listening attentively for your next command.

When Vector feels he's done something well, he does a proud little shimmy. When you don't need him, he'll potter around exploring his environment, and if he finds a new object, he might give it a curious little push. He's got cliff sensors built-in so he won't fall off any tables, but he does tend to get a bit nervous close to edges, apparently.

Anything Vector can do, you could do with your smartphone. But that's not the point, according to Anki CEO Boris Sofman. He has a theory that 'characterful' utility is going to one day trump basic utility, because in most cases, that's a more enjoyable form of interaction. No arguments here.

*Anki Vector*

£249.99, [anki.com](http://anki.com)

Meet Anki Vector. He's always pleased to see you and doesn't leave presents in your shoe. Unlike a cat





ARTIFICIAL INTELLIGENCE

# AI USES DEEP LEARNING TO FIND HEAT-RESISTANT CORAL REEFS

Thanks to 360° imaging and AI, scientists now know more about the state of our coral reefs

In the western Pacific lies the Coral Triangle, stretching across an area of 6,470,000km<sup>2</sup> and encompassing Indonesia, Malaysia, the Philippines, Papua New Guinea, Timor Leste and the Solomon Islands. While much of the Triangle has been experiencing its worst ever bleaching event, University of Queensland researchers have used artificial intelligence to discover that some of the reefs off Sulawesi seem largely resistant to ocean warming.

The team used underwater scooters fitted with 360° cameras to photograph 3,851km<sup>2</sup> of reef, creating a total of 56,000 images. They then taught a deep-learning program to identify different corals and invertebrates in the images – once it had been shown around 500 pictures, it was able to process the rest autonomously. The analysis found that the reefs around Sulawesi haven't declined significantly since 2014.

The study of these heat-resistant reefs has given researchers hope that some coral might survive the

damaging effects of human-induced climate change, and could replenish adversely affected reefs if we manage to stabilise ocean temperatures in the future.

Experts agree that coral reef ecosystems worldwide could collapse as early as 2050 if carbon emissions continue at the current rate. This research project is part of the 50 Reefs initiative, focused on gathering and analysing data on the reef ecosystems that are most likely to survive until global warming is brought under control.

## Coral bleaching

Corals get their colours from algae-like organisms called zooxanthellae, which provide food through photosynthesis. In periods of extreme heat, corals expel their zooxanthellae and turn white, which can lead to disease and starvation.



## ROBOTICS

# REMOTE-CONTROLLED ROBOT CUDDLES ARE HERE

You'll soon be able to get cuddles from loved ones overseas, even if they are a little cold and pointy. Researchers from Keio University and the University of Tokyo have developed a robot that can be worn as a backpack and operated by someone else who is wearing a virtual reality headset and handheld controllers.

The arms could give you a hug or a high five. Alternatively, you could attach the robot's wrists to your own, allowing the person wearing the VR headset and handheld controllers to manipulate your arms, a feature that could be used for instruction or physical therapy. Although this isn't the only time researchers have

given people extra arms, these are the first to be controlled by a remote operator using VR.

The robot is linked to a backpack PC that wirelessly streams data between the wearer and the operator. As well as the two robotic limbs, a robot head with two cameras peers over the wearer's shoulder, showing the operator what's going on. When the operator moves their head while wearing the VR headset, the robot head moves in response.

Though this is just a prototype, the researchers are working on turning it into a product, and exploring its potential uses. Meanwhile, we're eagerly awaiting our first remote robot golf lesson.

Yamen Saraiji (pictured) led the development of the robotic arms

## BOT BYTES



## BEGGING BOTS

In a new study, a robot begged participants not to turn him off because he was scared he wouldn't be turned on again. The robot's pleas convinced a third of the participants to leave him on, and most laboured over the choice, taking longer to decide than those who hadn't heard the robot's message.

## BARTENDING BOTS

Finally, after decades of progress, Microsoft has developed a robot that can fetch you a beer from the fridge. Designed to help receptionists with daily tasks, the robot can sense when a human needs help, answer questions, and fetch specified objects.

## BUDDY BOTS

University of Luxembourg researchers have developed QTrobot to help autistic children interact with human therapists and decrease discomfort during sessions. Children directed their gaze towards the robot twice as much as towards a human, and signs of discomfort and anxiety were decreased by two-thirds during sessions with the robot.





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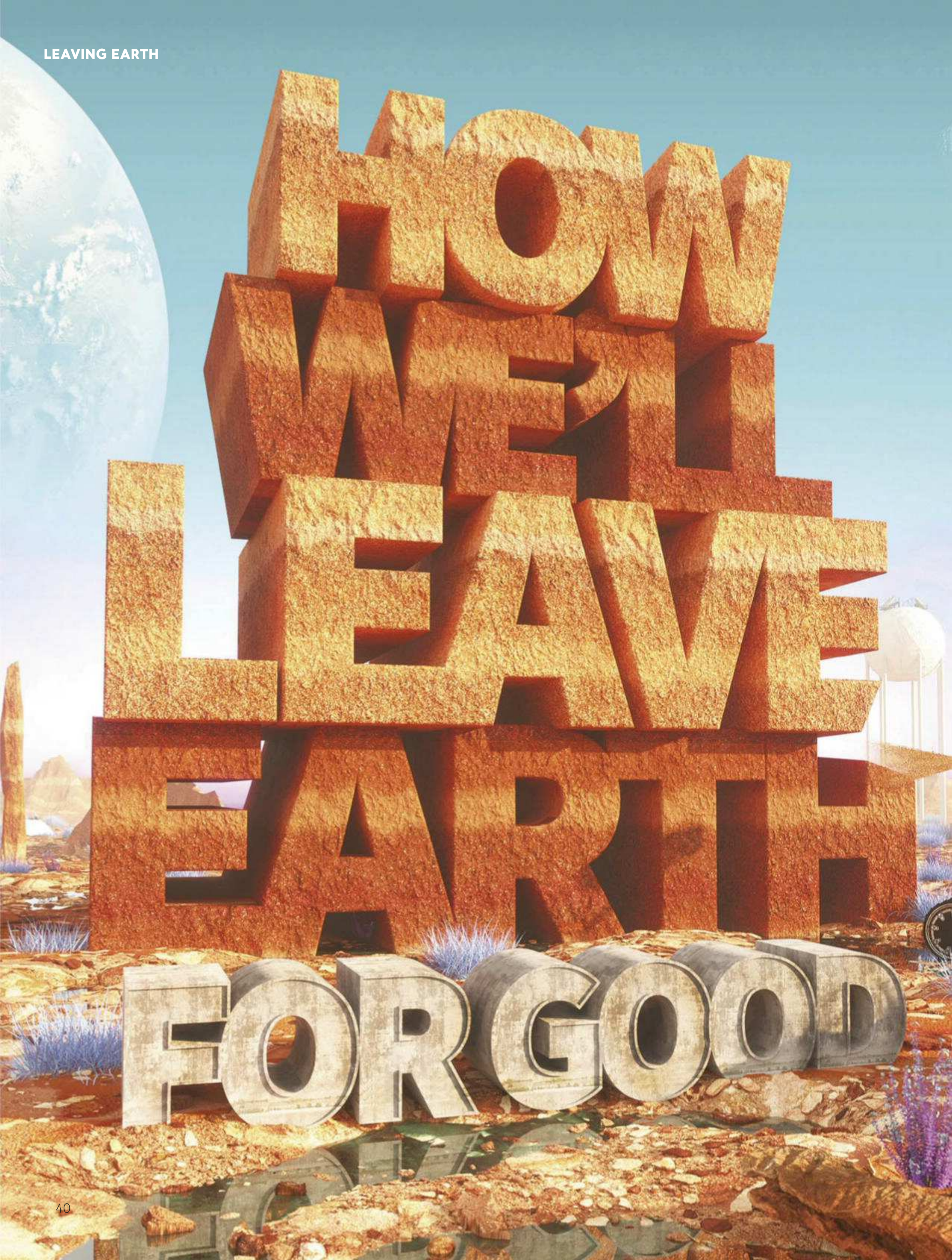


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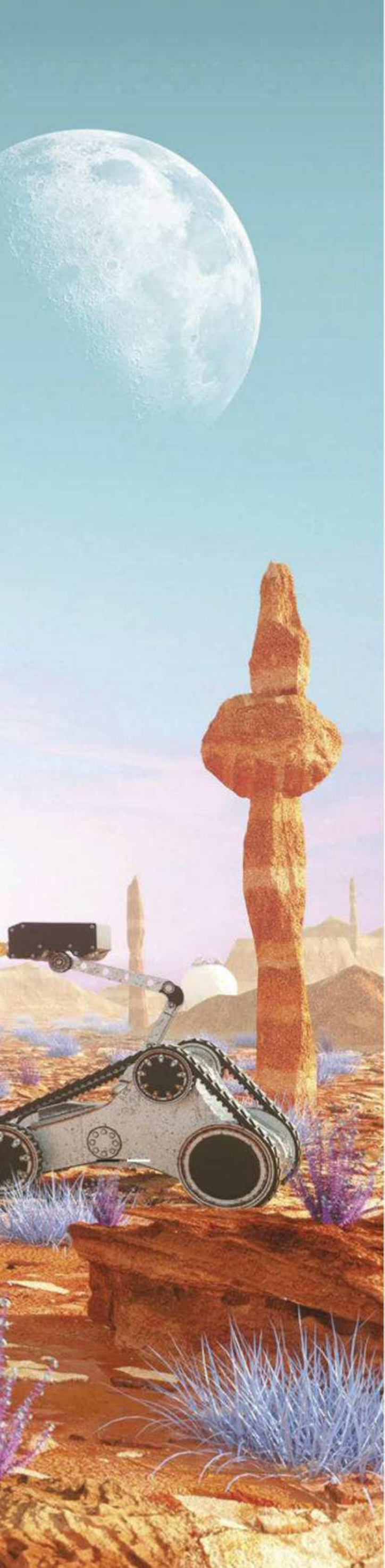


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In October 1968, the Apollo 7 mission sent US astronauts into space and kick-started the race to reach the Moon. Now, 50 years on, we look at some of the discoveries and technology that will help us set up a permanent new home in space

WORDS: COLIN STUART AND KELLY OAKES

**P**lanet Earth has been home to humans for hundreds of thousands of years, and it's served us well. But with the global population ever growing, and humans continuing to pollute and plunder the Earth's finite resources, our planet is looking increasingly imperilled. A 2012 World Wildlife Fund report estimated that by 2030 we'll need the equivalent of two planets in order to

sustain our lifestyles. And it's pretty much a certainty that we'll have to move at some point, with the Sun forecast to increase in brightness and boil away our oceans in around a billion years' time.

So scientists are beginning to look towards the stars, figuring out how we might one day set up base elsewhere. Over the following 10 pages, we look at the latest research into how we'll harness resources, build a settlement, grow food, make babies and stay healthy on our new home.

ILLUSTRATION: DUSK/FOLIO ART



# HARVESTING RESOURCES

## Asteroids will be plundered for materials and fuel

A new era of space exploration began in January 2018 with relatively little fanfare. A tiny satellite – Arkyd-6 – was lofted into orbit on board an Indian rocket. Designed and built by US outfit Planetary Resources, it's an asteroid scout tasked with searching out potentially mineable space rocks.

The thing about space exploration is that it's a constant fight against the relentless downwards tug of Earth's gravity. Taking everything you need with you from the outset means having to outrun our planet's pull, and that's super-expensive. It costs thousands of dollars to launch a single kilogram into orbit, even with the recent advances in rocket technology by companies like Elon Musk's SpaceX. Far better to launch light, harvesting what you need from space. And there are few places more enticing than asteroids.

As leftover building blocks from the formation of our Solar System, asteroids are rich in precious commodities such as platinum, tungsten and iron. The temptation they offer has triggered the cosmic equivalent of the famous California Gold Rush of the mid-1800s. Last year, Luxembourg became the first European country to pass a law that allows asteroid mining companies in the country to keep what they find in space. Meanwhile in the UK, Scottish aerospace company Asteroid Mining Corporation is currently trying to raise £2.3m to build satellites capable of identifying platinum on near-Earth asteroids. In the coming years, companies could send proof-of-concept probes to explore some of the 17,000 asteroids deemed close enough to reach economically, with estimates suggesting that an asteroid would have to contain

commodities worth in excess of \$1bn to make the daring trip worth it. The potential rewards are huge: some commentators suggest asteroid mining could produce the world's first trillionaire.

For now, though, asteroids offer something even more vital for future spacefarers: ice. Frozen water is the space equivalent of gold. Melt it and you have water to drink and wash with. But that's only scratching the surface of ice's potential: one look at its famous chemical structure –  $H_2O$  – tells you it's made of both hydrogen and oxygen. You can harvest breathable air from ice, as well as using the hydrogen for fuel. It means that asteroids could become the cosmic petrol stations of the future: dock, fill up and continue your journey. Mars, with its abundant ice in glaciers and polar caps, could also be a valuable pit stop.

"THE POTENTIAL REWARDS ARE HUGE: SOME COMMENTATORS SUGGEST ASTEROID MINING COULD PRODUCE THE WORLD'S FIRST TRILLIONAIRE"







LEFT: Future space colonies could mine asteroids for vital resources

RIGHT: Near-Earth asteroids are rich in valuable minerals – and in water ice

## HOW WE'LL GET AROUND



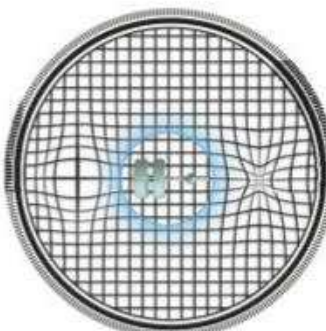
### Solar sails

We might one day sail around the Solar System. Huge canopies could catch the solar wind – the stream of charged particles blowing from the Sun. The technology has been demonstrated in miniature, and The Planetary Society's LightSail 2 mission, with 32m<sup>2</sup> of sails, is due for launch this November.



### Antimatter rockets

When a particle meets its antimatter equivalent, they annihilate into energy, which could power a rocket. Just 10g of antimatter could get you to Mars in four weeks! But it's not cheap to make: if CERN's particle accelerators exclusively made antimatter for a year, they'd create just a billionth of a gram.



### Alcubierre drive

Move over *Star Trek*, this is a warp drive for the real world. NASA is looking at manipulating space itself, so that you could travel faster than the speed of light without violating the rules of physics. The catch is you'd need to have negative mass in order to do so, and we don't yet know if that's possible.



### Space elevators

If you could slowly climb an elevator shaft that was anchored to the equator, Earth's rotation means that at the top you'd be orbiting the planet fast enough to fly off into space. While still a long way off, thanks to recent advances in materials science we may soon have something to build the cable from.



### Fill up en route

Rather than taking all their fuel with them, future missions could harvest methane – the main component of natural gas – from places like Mars, Jupiter and Saturn's largest moon, Titan. Last year, Jeff Bezos's space company Blue Origin successfully test-fired its BE-4 rocket engine, which is powered by liquefied natural gas.



# BUILDING A HOME

## Welcome to the space village

Humans are fragile beasts whose sensitive biology needs a lot of protecting. This is particularly true away from the protective cocoon of our planet's atmosphere and magnetic field. So if we're to set up shop elsewhere, we're going to need to fashion ourselves some decent accommodation. Shipping a construction kit from Earth is prohibitively expensive, so the buzz acronym right now is ISRU – In Situ Resource Utilisation. Which is a fancy way of saying: “use what's already there”.

Plans are already underway. In July this year, NASA announced the five winners of its \$100,000 ‘3D-Printed Habitat Challenge’ to design a dwelling that would enable people to live and work on Mars, and which could be built using local materials and 3D-printing technology. First place was awarded to Team Zopherus of Rogers, Arkansas, who designed

an uncrewed, robotic printer that would land on the Martian surface and deploy rovers to gather local materials. The European Space Agency is also currently working out how to 3D-print building blocks for future space habitats using lunar soil.

Putting up a habitat is a good start, but looking longer-term we might want to ‘terraform’ our new home and make it more Earth-like. This wholesale makeover means fundamentally altering the atmosphere and temperature to create an environment that's more amenable to liquid water and life. A study published in June found that an ancient group of microbes called ‘cyanobacteria’ can photosynthesise in extremely low-light conditions, a boon that could one day see them deployed in sheltered areas on toxic planets to take in carbon dioxide and pump out oxygen. Mars is one possible candidate,

although another recent study suggests that the Red Planet might not have enough carbon dioxide to do the job.

Fashioning a house is not the same as making a home. For any colony to be successful, its inhabitants have to function as members of a fledgling society. That's just as much about the people as it is bricks and mortar. The first settlers will need to draw up a legal system to maintain law and order, perhaps based on our current laws here on Earth. Jobs will need to be created and assigned to those with suitable skills, and institutions will have to be set up quickly to provide medical, educational and economic services. Ideally, this will all be planned before the spacegoers have left Earth, as there'll be enough to think about on our new home without having to create a functioning society on the hoof!

NASA X2, GETTY X3, ALAMY, AI SPACEFACTORY/PLOMPZOES

“THE EUROPEAN SPACE AGENCY IS  
CURRENTLY WORKING OUT HOW TO  
3D-PRINT BUILDING BLOCKS FOR FUTURE  
SPACE HABITATS USING LUNAR SOIL”



## WHERE WE'LL GO FIVE POTENTIAL DESTINATIONS



**Location:** The Moon  
**Distance from Earth:** 384,400 km (average)

**Pros:** Could evacuate back to Earth in an emergency. A great testing ground for new technology. No communications delay to speak of.

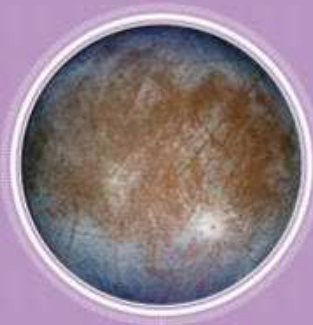
**Cons:** Nights that last two weeks. No atmosphere or magnetic field for protection. Wildly fluctuating temperatures.



**Location:** Mars  
**Distance from Earth:** 225 million km (average)

**Pros:** The only planet in our Solar System that's not either too hot or made of gas. Plenty of water ice. Relatively close.

**Cons:** No magnetic field to protect against radiation. Vicious dust storms the size of continents. Communications with Earth delayed by 20 minutes.



**Location:** Europa (moon of Jupiter)  
**Distance from Earth:** 628 million km (average)

**Pros:** More liquid water than all of Earth's oceans, lakes, rivers and seas combined.

**Cons:** In the firing line of intense radiation belts created by Jupiter's magnetic field. Vulnerable to meteorites pulled in by the Solar System's biggest planet.



**Location:** Interplanetary space  
**Distance from Earth:** > 1 million km

**Pros:** Movable. Unlimited space to build a habitat orbiting Earth or another planet – you aren't restricted by topography. Gravity could be recreated to match Earth's.

**Cons:** You'd need to build and assemble everything from scratch, with no help from the landscape.



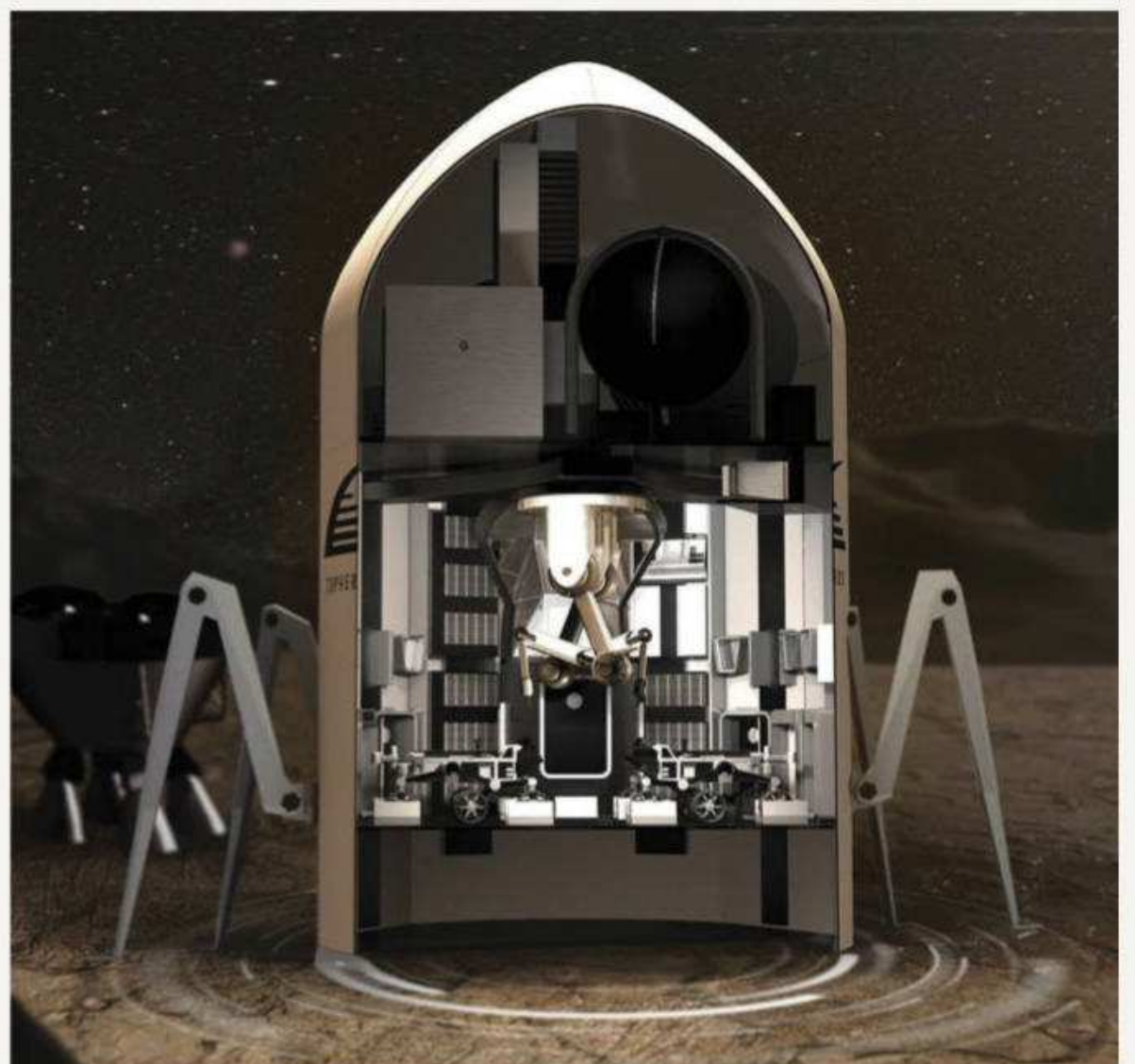
**Location:** Kepler-438b  
**Distance from Earth:** 470 light-years (4.4 quadrillion km)

**Pros:** One of the most Earth-like exoplanets found so far. Sits on the inner edge of its star's habitable zone.

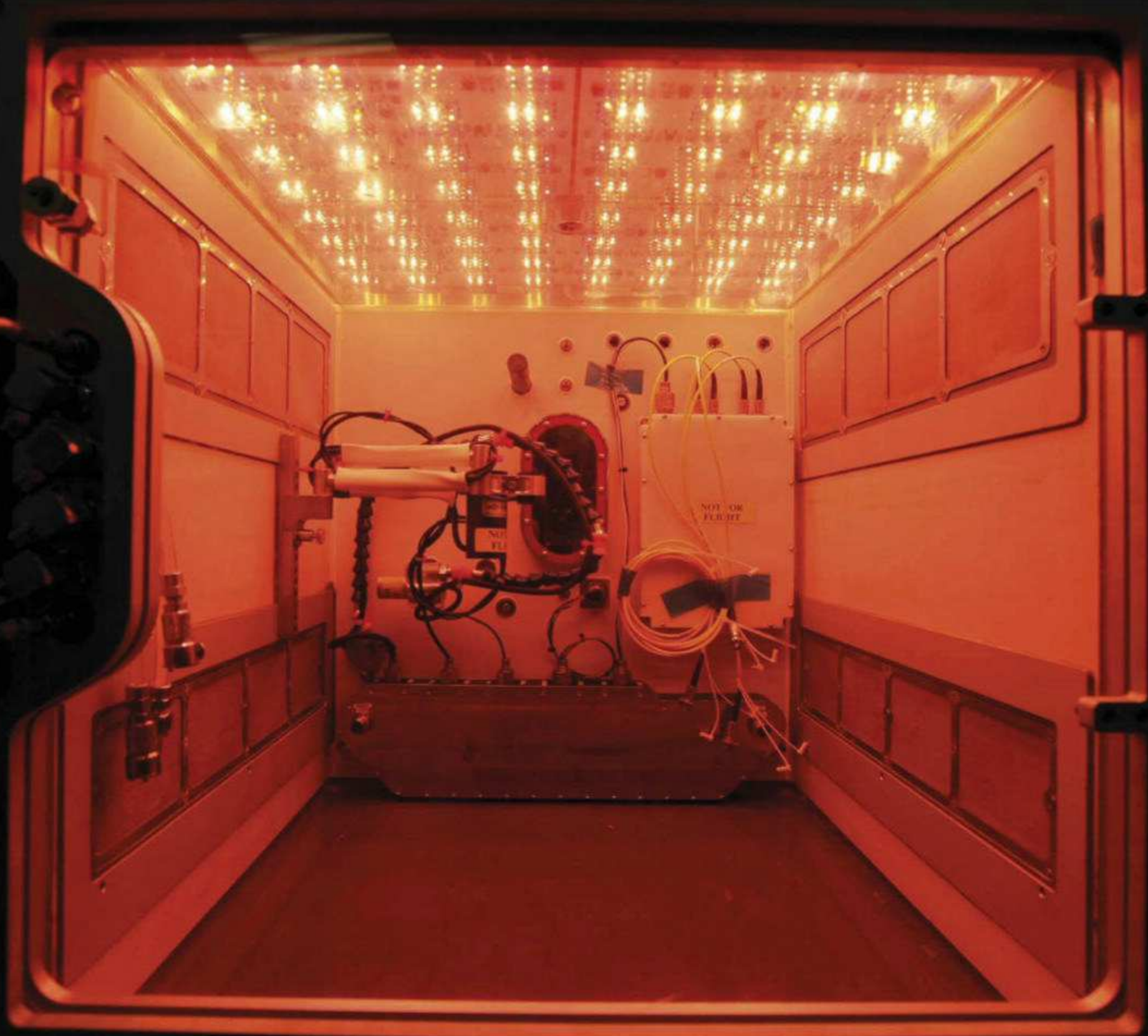
**Cons:** Would take more than a human lifetime to reach. Orbits a red dwarf, which are thought to have potentially life-destroying solar flares.

LEFT: AI SpaceFactory's entry came second in NASA's 3D-Printed Habitat Challenge this year

RIGHT: Team Zopherus's winning entry in the same competition was a roving 3D printer







# GROWING FOOD

## What will be on the menu?

On Earth, vegetarianism and veganism are on the up and up. In space they'll be a necessity: there simply aren't enough resources to sustain livestock. So plants it is – but which crops grow best in the harsh arena of space?

Earlier this year, the first green shoots were seen in the International Space Station's Advanced Plant Habitat (APH) – a growth chamber the size of a mini-fridge. The plants, a small batch of dwarf wheat and *Arabidopsis* (flowering rockcress), are automatically tended by a computer-based system known as PHARMER, which uses 180 sensors to monitor variables such as temperature, humidity and light levels.

This technology complements the ISS's Vegetable Production System (known as 'Veggie'), which is designed to produce salad ingredients. In 2015, astronauts sampled the first lettuce grown in space. The projects haven't been without their problems, however. Just as on Earth, mould has been a big issue that's stopped scientists moving on to growing more interesting food like tomatoes. Space gardening is tough, but these are all useful lessons for our first cosmic farmers.

Meanwhile, other scientists have been looking into the possibility of growing plants on Mars. Researchers from Villanova University in Pennsylvania have been

running the Red Thumbs Mars Garden Project. They simulated the Martian soil by taking dirt from volcanoes on Earth, and tried growing a range of crops including kale, garlic and potatoes. Light levels were carefully controlled to match those found on a dimmer planet further from the Sun. The kale grew well, but the clay-like soil was too dense for the growing potatoes to expand and thrive. However, a similar experiment at the International Potato Center in Peru *has* managed to grow potatoes in Mars-like conditions by using spuds that have been specially bred to tolerate harsher environments – offering hope for all future spacefaring chip-lovers.





## "IN 2015, ASTRONAUTS SAMPLED THE FIRST LETTUCE GROWN IN SPACE"

LEFT: NASA's Advanced Plant Habitat is a recent addition to the Space Station

ABOVE: Kale grown in 'Martian' soil, which actually came from volcanoes here on Earth

ABOVE RIGHT: NASA's Steve Swanson tends to the Vegetable Production System on-board the ISS

The real breakthrough could come if we master the art of synthetic biology – the ability to design, engineer and build biological structures from the ground up. Why try and make earthly plants eke out an existence on Mars when you can engineer new ones specifically designed to thrive there? Automated mini-factories known as biofoundries can test millions of different designs at once by growing various organisms in the lab under strictly controlled conditions. That way, researchers can home in on those species that are hardy enough to survive. In July, a team of Australian scientists published a paper calling for wider investment in the field, suggesting it could become a reality in as little as a decade.

## COULD WE EAT OUR OWN POO?

Scientists at Penn State University have developed a novel way of making food, which would save us having to lug all of our food with us into space. Yesterday's human waste is transformed into tomorrow's lunch.

Urine is already recycled into drinkable water on the ISS, but faeces are sent away in a cargo vessel to burn up in Earth's atmosphere. Dr Lisa Steinberg, who worked at Penn State before becoming a school science technician, saw this as a wasted opportunity, and developed a system to reuse all of our bodily outgoings.

"The system is composed of two reactors," she says. "The first takes urine and faeces and converts part of the carbon [in the waste] into methane, which is fed to a second reactor

growing a methane-consuming bacterial biomass." The result is a high-protein, high-fat food supplement. Steinberg points out that the food can be grown within a few days – much quicker than plant-based protein sources such as soybeans. However, she cautions that it "would likely complement, not replace, vegetable matter in an astronaut's diet."

Is it safe? "[The reactors] only transfer gaseous products, which can be easily filtered to remove pathogens," she says. "Safety was an important priority." As for the taste, Steinberg's team weren't able to sample the food due to lab protocol, but the texture has been described as similar to Marmite. Whether astronauts can be convinced to eat it is another matter.



One of the International Space Station's two toilets



# STAYING FIT AND HEALTHY

Make friends with the  
space gym

Our bodies don't react well to the low-gravity environment of space. Our muscles don't have to work as hard, so they start to waste away. Our bones get weaker and our heart pumps blood slower. To counter this, astronauts spend two hours each day exercising to stave off muscle and bone loss. For a long-duration mission, we'll need to follow a strict exercise plan, unless we can invent a spacecraft with its own artificial gravity so that the body behaves as it does on Earth.

Past space missions have given us plenty of insight into the physical effects of space, but there's one major aspect that has, until recently, been neglected – the microbiome. Over the past few years, scientists have become increasingly aware of the crucial role that our body's army of microbes plays in our health, linked to everything from cancer and obesity to depression and diabetes. So how might our microbiome fare in space?

In March 2015, NASA astronaut Scott Kelly began a year-long stay aboard the ISS – the longest that anyone had spent there – as part of a mission to study the long-term effects of spaceflight on the body. Now, researchers are poring over the data.

“If you're sending a person into space, you're not just sending a person,

you're also sending trillions of microorganisms,” says Dr Martha Vitaterna of Northwestern University, one of the scientists studying Kelly's microbiome.

A diverse gut microbiome is generally thought of as healthy, but both diet and stress can change it pretty quickly. Because Kelly's diet on the ISS was so restricted, Vitaterna says that the team expected to see a significant decrease in the diversity of microorganisms in his gut, but preliminary results show that this didn't happen. What's more any changes that did take place went back to normal fairly quickly once he returned to Earth.

Another NASA project is set to shed even more light on the microbiome in space. Earlier this year, the Rodent Research-7 experiment sent mice to the ISS in a bid to find out how changes in the rodents' microbiomes impact other aspects of their health, including their sleep and circadian rhythm. The results aren't expected until next year, but they should help us to understand how humans' microbiomes, and sleep patterns, might change in space. And if they back up the Scott Kelly study, it'll be good news. When we do eventually leave Earth for good, we might lose bone and muscle mass, but perhaps we'll get to keep our microbes.



“ASTRONAUTS SPEND TWO  
HOURS EACH DAY EXERCISING  
TO STAVE OFF MUSCLE  
AND BONE LOSS”





LEFT: NASA astronaut Cady Coleman tests out the ISS's Cycle Ergometer

RIGHT: Mice have been taken onto the ISS to study the effects of microgravity on the body

NASA X3, GETTY, ESA

## HOW WE'LL STAY SANE



### Good communications

If we go to Mars, we'll face a satellite communications delay with Earth of up to 22 minutes. Alongside the physical challenges, this presents a mental one. In the Mars-500 mission – a 17-month simulated Mars mission based in Moscow – the crew had five times as many conflicts with Mission Control as they did among themselves. If we're going to leave Earth, we'll need to get used to a laggy connection with those still back at home.



### Artificial light

Leaving planet Earth, and losing the 24-hour day/night cycle, could play havoc with our body clocks. In Mars-500, four out of six crew members suffered sleep disorders, with one becoming chronically sleep-deprived, and another shifting their sleep schedule out of sync with everyone else. On a spaceship, this could be overcome with artificial light that mimics natural daylight on Earth. On an alien planet, it could prove to be a tougher problem.



### Great entertainment

"Are we nearly there yet?" is going to be a common question on a months-long journey through space. We know greenery on Earth helps reduce stress, so growing food or vegetation on-board could be one leisure activity with added benefits. Another option is virtual reality. At HI-SEAS, a NASA-run simulated space mission housed on a volcano in Hawaii, crew members could escape to their own bespoke VR world through a headset.



### A support network

Astronauts invariably say that seeing Earth from space is a profound experience. But what happens when you can no longer see Earth at all? It's thought that 'Earth-out-of-view phenomenon' could lead to anxiety, intense homesickness and depression, especially if family and friends have been left behind. Space pioneers will need a strong social and psychological support network on their new home, to help those who are feeling the effects of leaving Earth.







# MAKING BABIES

It's a little more difficult in space...

If we're going to successfully leave Earth, we'll need to figure out how to conceive in space. One potential hurdle is the effects of weightlessness on sperm – something that's currently being investigated by NASA.

In April this year, the Micro-11 project sent human sperm to the ISS for the first time. Researchers are still awaiting the results, but previous work from the same team has shown that bull and sea urchin sperm fare pretty well in space. The bull sperm move faster in microgravity (a trait that's generally associated with higher fertility), while, in sea urchin sperm, the chemicals that get the sperm cells to start swimming also kick in faster.

"Given what we know from the previous data, our hypothesis is that [human] sperm are going to be found to swim faster in microgravity," says Dr Joseph Tash at the University of Kansas, leader of the Micro-11 project. If this does happen, he hopes the project will be able to figure out why.

But sperm is only half of the equation. Previous experiments on Space Shuttle missions with female mice suggest that microgravity delays the release of mature eggs from ovaries. Tash has got another experiment in

the works to test whether this is a long-term effect – if it is, it'll be another bridge we need to cross.

Another obstacle to making space babies might be high-energy cosmic rays and the charged particles streaming from the Sun. While radiation levels on the ISS are 10 times higher than on Earth's surface, they're nothing compared to levels outside the protection of Earth's magnetic field, which acts as a deflective shield. Radiation can stop sperm and eggs from being produced, and can also cause mutations, leading to damaged fetuses. We'll need to find ways to shield space travellers from these effects with radiation-proof habitats, or medicines that can help repair DNA damage.

Once we've got over these biological hurdles, we'll also need to make sure that we send enough people to our new home to keep the gene pool healthy and avoid inbreeding. One hypothetical plan for a 6,300-year trip to nearby exoplanet Proxima Centauri b estimates as few as 98 people would be enough to prevent inbreeding. Others think a crew on the order of thousands is a better bet for such a long mission, to cope with the possibility of a catastrophic event and keep the crew as healthy as possible.



## Q&A: HOW TO RAISE A CHILD IN SPACE

How can we ensure that our space babies grow up happy? We speak to Portland State University anthropologist DR CAMERON SMITH

### Can it be ethical to raise a child in space?

Philosophers call this concept 'consent to risk'. Is it morally acceptable to subject somebody to risk without their consent? In this case, I think it is.

Compare it to the people of ancient Polynesia. Three thousand years ago, they set out across the sea looking for new islands. Often entire families went together and were never heard from again. But eventually they colonised the entire Pacific Ocean. Would we call that unacceptable? I don't think so – they were explorers.

### What are the potential risks?

The challenges are both biological and cultural. There'll be a period when the earliest settlers in space will have higher infant mortality, because we won't know how to adapt to all the conditions right away. Children will also develop differently under different gravity. Having children in space will require a culture that's ready to take on those risks and discomforts.

### How can we ensure they have a happy childhood?

What we think of as a normal life for a child here on Earth won't be the same on another planet. In some ways, children will have less freedom. By the age of 10, I could go out exploring by the creek. On Mars, it will be much more dangerous to go outside for a wander.

However, the early years of space settlement will be so carefully planned that children born in space will have a much greater chance of having the food, water and resources they need for a happy life, compared to the average person born on Earth today, where those are rarely guaranteed.

### How should we prepare?

What I'd want to do is give the space settlers everything we know about human adaptability, and let them shape their lives themselves. In the end, we can't predict everything – we have to rely on the adaptability of humanity.

"IN APRIL THIS YEAR,  
THE MICRO-11 PROJECT SENT  
HUMAN SPERM TO THE ISS  
FOR THE FIRST TIME"

Any children born in space will grow up in a very different world from our own



**Kelly Oakes** is a science writer based in London.

**Colin Stuart** is an astronomy author. His latest book, *How To Live In Space*, is out on 4 October (Andre Deutsch, £16.99).



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INTERVIEW

# IT'S TIME FOR CHANGE







GIRLS ARE NOT PICKING  
AS MANY STEM A-LEVELS  
AS BOYS, WHILE PROFESSIONAL  
FEMALE SCIENTISTS ARE DROPPING  
OUT OF THE FIELD. DOES SCIENCE  
HAVE A PROBLEM WITH WOMEN?

**WORDS: ALICE LIPSCOMBE-SOUTHWELL**

#### DISCOVER MORE

You can read the full unedited interview, watch the video, or listen to the podcast at [sciencefocus.com](https://www.sciencefocus.com). We'll be following up on this in a future issue of *BBC Focus* – look out for it.

**B**ack in the 19th Century, Ada Lovelace carried out pioneering computing work on the Analytical Engine with Charles Babbage, at a time when few women were schooled in maths and sciences. Ada Lovelace Day falls on 9 October this year: its aim is to increase the profile of women in these careers and inspire the next generation of scientists, engineers and mathematicians. This is important, because there are around 40,000 skilled STEM jobs left vacant each year in the UK.

The UK's growing science, engineering and technology industries are crying out for people with STEM A-levels, yet students appear to not be selecting these subjects. This is particularly marked among girls, with just 19 per cent choosing two STEM subjects at A-level compared to 33 per cent of boys. According to the campaigning body Women into Science and Engineering (WISE), computing, further maths and physics at A-level have particularly low proportions of female entrants, at 10, 28 and 22 per cent respectively.

Women who do continue on to a science-based career therefore end up in a minority, making up just 23 per cent of people in core STEM occupations. Numbers are slowly rising, which is encouraging, but here at *BBC Focus* we wanted to understand more about what's keeping young women from choosing STEM subjects and careers, and why women have a tougher time reaching the top and staying there. Here we talk to four women currently working in STEM about their experiences, the problems faced by women and girls, and how we can fix the issues... ➤



## DR SUZIE IMBER

@SuzieImberSpace

ASSOCIATE PROFESSOR  
OF PLANETARY SCIENCE  
AT THE UNIVERSITY  
OF LEICESTER. LAST  
YEAR SHE WON THE  
BBC TWO SERIES  
*ASTRONAUTS: DO  
YOU HAVE WHAT  
IT TAKES?*



► **What inspired you to get into STEM?**

**Aoife:** I was lucky, I had a family that was pro-maths. I always just followed the thing that I loved, despite getting quite a low mark at A-level maths! I pursued it onto degree level, despite advice from teachers saying I definitely shouldn't do it.

**Jess:** I equally grew up among scientists. My parents are both medical doctors, and I think that I was always fascinated by understanding the world around me a bit more. And I had really, really great teaching at school. And then I went to art school before doing physics at university.

**Suzie:** I wasn't great at science, actually. I wasn't bad at it, but I wasn't great at it for a long time when I was at school. But again, my parents are fairly scientific and I think that's helpful. I have a twin brother and he's a neutrino physicist, so family dinner conversations are fascinating these days. And again, not being brilliant at it, if you work hard enough, you can get to where you want to go.

**Angela:** Well, I'm not really a scientist any more. I'm someone on the other side, if you like. But I did study engineering at university, and part of the reason I think I did that was because my dad

**“Reaching out when they’ve chosen GCSEs or A-levels – it’s too late”**

ABOVE: After winning *Astronauts: Do You Have What It Takes?* Suzie is keen to apply to ESA in future to become a real-life astronaut

had been an engineer. In my culture, in India, where my family are from and where I've lived, engineering is a really prestigious, high-valued thing to do. I never had this sense that I think a lot of other people in my school had that it was getting greasy and dirty and being a mechanic. For me, it was an exciting route to understanding how things work. You know – taking things apart and fixing them and building new things. That was what I really loved about reading engineering. It was just making things all the time. So I miss that now, although I do make all the flat-pack furniture at home and do all the DIY!

**Research suggests that students are encouraged to get great results at A-level to get into**



university, and people are maybe put off doing STEM subjects because they think it's going to be really hard to get high grades. Yet some of you say you didn't necessarily get the top results in science and maths subjects...

**Suzie:** Yes, I hear that all the time from students. So, 'Oh, physics is really hard,' or they think that they'll get As in other subjects and physics would be harder to achieve that. If that's what's putting people off, that's such a shame. They're missing an opportunity there.

**Aoife:** The perception that it's hard to do well in maths is something that's really stubborn. Maths was the most popular A-level in 2016, of all of the A-levels. For an average A-level, you'd expect around 26 per cent of people to get As and A\*s, but in maths it's more like 60. But there's still a stuck view that it's difficult, and that's something we all need to work together to get over. You don't need to be the top of your class to go on and work in STEM jobs. Often we don't look for the highest grades – we look for logical, thoughtful, motivated problem-solvers.

**Jess:** Most parents especially want their daughters to become doctors or teachers, and as a result, subjects like chemistry, which is required for university medicine, is completely gender balanced at A-level. So if they made physics a requirement for university medicine, it would be completely gender balanced at A-level overnight. There's evidence that if you've got a physics A-level, you make a better first- and second-year junior doctor.

BELOW: Angela's book *Inferior* uses hard facts, research and evidence to dispel myths about gender that are perpetuated to this day

**Suzie:** I think there's also evidence that we need to look at a younger age. Reaching out to them when they've done their GCSEs and chosen their A-levels, it's actually too late. They've made a decision about themselves: I'm not a scientist.

**What can parents be doing to encourage their boys or girls to look at STEM careers? How soon can they start introducing those ideas to their children?**

**Angela:** I think making things, building things, doing experiments at home... these are easy things that can be done, and they really are the linchpin of not just generating an interest in a young child in that subject. And with things like coding: it's useful to understand the logic of how to code. It's so simple. A five-year-old can do it. There's no reason why that kind of thing can't be done at home.

**Jess:** Programming you can do at home. There's Hour of Code online, where you can do challenges all the time, but there are so many teaching resources on the BBC website and elsewhere, so you can do all of that for free. And the maker movement is really well established now across the UK. This idea that you can rock up to a Maker Space – look for one near you – and they'll teach you at an age level that's appropriate for who you are, skills to tinker and to play, whether it's with Lego, woodwork or metalwork.

**Angela:** We have loads of research now that shows that if you encourage children in certain areas of play, that helps to develop their

AWARD-WINNING  
SCIENCE JOURNALIST  
WHO WROTE  
*INFERIOR: HOW  
SCIENCE GOT  
WOMEN WRONG.*

ANGELA SAINI

@AngelaDSaini



# IN NUMBERS



22%

The percentage of physics A-level exams taken by girls this year



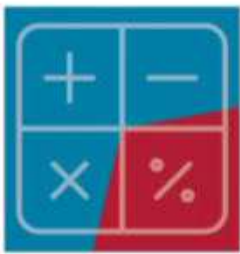
1 in 5

The number of girls who take two STEM subjects at A-level



5%

The percentage of registered engineers and technicians who are women



37%

The percentage of girls who took A-level maths after achieving A\* or A at GCSE, compared to 51% of boys



80% of university vice chancellors in the UK are male



43%

The percentage of STEM A-levels awarded to girls this year

“The boys don’t face the discrimination, the barriers or the sexism that girls do”

**Jess:** I think even in things like medicine and genetics, though, that’s true early on in your career. There aren’t many women professors in medicine. You don’t have as many senior consultants in hospitals. It’s the same issues, the structural ones. And they’re the kind of big, structural changes we need to make within the scientific community to keep women there.

**Could these issues be related to childcare?**

**Angela:** Yes, I think that’s an enormous issue. And certainly I structured my career around the expectation that I would be taking the lion’s share of the childcare when I had my son, which is exactly what happened. I’ve turned down really good opportunities because of the childcare situation. And it’s not just childcare, we kind of relegate everything outside work because we think it doesn’t matter. It does matter. There are lots of accomplished professional women who give up work or who go part-time because they want their children to have a parent at home. They want to be part of their children’s lives, and they want their child to have someone. Generally, even though we have paternity leave now, men aren’t taking on that role. And often, it’s because they don’t want their careers to take a hit. So it’s the same fear that we have; it’s just that they’re less likely to do it.

**Suzie:** And I think there’s also a time issue here in the sense that when you’re in your 30s, that’s a really big moment in your scientific career. You’ve got your PhD, you’ve been a post-doc for a few years, you’re applying for fellowships, and

• brains and skills in that direction. One of the reasons that we have the gender stereotypes we do is because girls are given a certain set of toys, boys are given a certain set of toys, and they do actually develop along those [gendered] lines because of that social input.

**With subjects like medicine, there seems to be a good gender balance, whereas in engineering, physics and space, women and men aren’t equal in numbers. Some figures suggest it’s going to be 250 years before physics is balanced male to female...**

**Jess:** I think it’s 250 years for physics papers to be balanced, so for the number of citations for men and women to be equal on papers. It’s not 250 years for it to be gender-balanced. That will probably take even longer.

**Angela:** But that’s extrapolating from the data that we have now. Things could change. I mean, 300 years ago, if you’d said women would have the vote by the end of this century, and in the same century be working alongside men doing everything they do, you would never imagine that. Society doesn’t work the way we statistically expect it to.



then you're going for that permanent job. That's a really critical moment. And so, possibly, if you then go part-time, it's perceived negatively when you're going for that big step. I think attitudes are changing, actually, and I think we need to improve things like flexible working and job-sharing. I'm not so special that I can't share my job with someone else!

**Do you think women tend to suffer more from a lack of confidence or put too much pressure on themselves in school and university?**

**Angela:** When I was at school, in my chemistry class, there were eight of us, and I was the only woman. I got the highest grades, and there were a lot of boys in that class well below average. It never bothered them that their achievements and academic levels were below standard. It really bothered the girls. When you know you're going into an industry where you're already going to face challenges because you're in a minority, where every stereotype message tells you that things will be really hard for you, you think, 'Well then I have to be brilliant in order to be able to do that. Because things are going to be hard enough for me anyway.'

The boys don't face the discrimination or the barriers or the sexism that the women do, and the girls know that. I felt I needed to be better than everybody else to do engineering – a degree which is so easy to get into in this country. You don't need to be brilliant to do it, but I felt that you did, because I was a minority.

**Aoife:** Absolutely. Certainly in maths, girls underestimate themselves, so like-for-like ability, girls and boys will rate themselves at different levels from about the age of 10, and it goes down from there. So you have this situation where you could have the same grade, you could both have an A or a B at the end of your GCSEs, and be looking at A-levels, and the girl is more likely to think that grade is not good enough for that step. And the confidence in your ability is a big predictor of whether or not people will go on and do that subject. We are losing out on some amazing talent by not having enough women going through the system into these jobs. We are going to need 1.8 million engineers by 2025, so we need to make sure we are widening the net.

**Angela:** But I think we underestimate the extent of discrimination within the industries themselves. Engineering has been a very sexist industry for a long time. I still meet women who tell me that they, against all advice, went and got their physics or engineering degree, and when they applied for jobs, even though they did just as well as everyone else, the boys got more call backs. So you do have to be better. We're told that you have to be better. We know that. And it's not the girls' fault for being underconfident, it's the industry's fault for not giving them the jobs at equal rates to men.

**Suzie:** But I think talking about perceptions, it's also one of those things where students have historically looked at a physicist and ➡

BELOW: Aoife will be presenting a BBC documentary about the maths of crowd flow later this year, and is also appearing at Maths Fest 2019

ASSOCIATE DIRECTOR AND MATHEMATICIAN  
AT MOVEMENT STRATEGIES, WHICH  
IS A COMPANY THAT SPECIALISES  
IN CROWD FLOW PLANNING.

**DR AOIFE HUNT**

**@Aoife\_Hunt**





# DR JESS WADE

@jesswade

PHYSICIST AT IMPERIAL COLLEGE LONDON. THIS YEAR SHE WON THE DAPHNE JACKSON PRIZE FROM THE INSTITUTE OF PHYSICS.

ABOVE: Just before we interviewed Jess, she'd launched a fundraising campaign to get a copy of Angela's *Inferior* into every secondary school in the UK. In just 12 days she achieved her goal

● seen middle-aged white men, and that's the perception of what a physicist is. Often they're enthusiastic about physics, and I'll say, 'Oh, are you going to study physics? You sound like you really like it,' and they say, 'Oh, no, I can't.' So I think it's for all of us to stand there and say, 'Well actually, we have, and you're just like us, so there's no reason that you shouldn't do that.'

**Jess:** Something really nice that the Institute of Physics did was getting 14- or 15-year-olds, so just-deciding-GCSE age, to go into primary schools to be ambassadors for their subject. Because when you're studying these things, then if you go and tell kids about it, you're the boss, right? You know way more than them, so you get really empowered on your own confidence. They get to find out about physics, which they've never really found out about before. It inspired both sides. It got those people to stay on and keep physics for A-level.

**Jess, you've recently been in the news because you started writing up Wikipedia pages for female scientists. What inspired you to do that in the first place?**

**Jess:** Wikipedia is this incredible educational platform. It's the fifth most accessed website in the world, and while people are critical about the level of referencing, and there are rumours that teachers say you shouldn't use it in schools,

it's actually a phenomenally good source for putting together different points of view, and the citations are really strict. But on English-speaking Wikipedia, only 17 per cent of the biographies are about women. So it's incredibly biased by the people who create the content. About 8 to 16 per cent of editors are women.

So basically, men are editing Wikipedia, and writing content that they're interested in or familiar with. Women are underrepresented in science and engineering anyway, and so are people of colour and LGBTQ+ scientists. I want it to be a neutral platform. And I think obviously that's going to take a lot more than just me editing it, but I decided at the beginning of this year that if I met awesome women or came across them on the internet, or awesome people of colour, I would start to make their Wikipedia pages. Then you start to look them up and learn about them and their story, and they're so inspiring.

**There have been stories recently about women who've had some nasty experiences – whether at undergraduate or PhD level – where they've been sexually harassed by supervisors or lecturers. Do you think this is particularly a problem in STEM?**




**Jess:** I think it probably is, historically, a bigger problem in subjects where men have dominated senior positions. So all these stories that are coming out about sexual harassment and bullying are in industries where men are at the top: in the film industry, in academia, in subjects like physics and engineering, where men are largely in positions of power. You have laws and rules in universities that are incredibly dated, that are hundreds of years old. There's nothing transparent about reporting the way that someone behaves. There's nothing clear about what will happen to that person if you tell them off. And I think that that's coming to a head now. Lots of these stories have come out in astrophysics, and that's because women are starting to get to about 30 per cent, and this is the kind of nominal percentage where things start to change. There's kind of a cultural shift, and the women start speaking up.

**Angela:** There have been some really high-profile astrophysics sexual harassment cases. And the question is, 'Why now?' Part of it is the #MeToo Movement, and women feeling braver to speak out. But it's also because they have each other. And they didn't always have each other.

I think one of the reasons it's worse in STEM, and particularly in lab research, is because this is a small, closed atmosphere, an environment where sometimes there'll just be a few people. You may be alone with your supervisor quite often, and there's nothing you can do about it. This person will be older, you'll generally be very junior, and your entire career can depend on them. It's no different from a Hollywood casting room in that sense. It's an environment ripe for abuse, really.

## “We go on about science’s lack of women, but it’s because they’re leaving”

**Jess:** There's an Athena Swan award that UK universities can compete for. It's kind of a gender equality kitemark. A bunch of senior female academics got together and said, “We're going to make an award scheme where grant money will depend on your ability to get one of these awards, and you'll get bronze, silver or gold depending on your commitment to improving the scientific community for everyone working there. For undergraduates, postgrads, professors, everyone.” Whether you're a woman, or a person of colour, or an LGBTQ+ scientist, all of these add up, and this makes you much more vulnerable to these positions of power. We go on and on about science's lack of women, but it's because they're leaving. Whether it's a huge sexual harassment case, or it's something really big that's happened, or it's just these constant knocks to you because of your gender.

**Suzie:** But these things don't change overnight. And you know, bringing in a policy now is really helpful. But we have to recognise that it takes years of work to change this kind of thing. It doesn't just change in a heartbeat. 

---

Alice Lipscombe-Southwell is the production editor at *BBC Focus*.

## FIND OUT MORE

Here are some of the excellent resources mentioned by our panel:

### WOMEN'S ENGINEERING SOCIETY

Supports and inspires women in engineering and science.

[wes.org.uk](https://wes.org.uk)

### 1752 GROUP

Research and lobby group working to end sexual misconduct in higher education.

[1752group.com](https://1752group.com)

### HOURL OF CODE

One-hour coding activities to encourage people of any ability to get involved in computer science.

[hourofcode.com](https://hourofcode.com)

### LET TOYS BE TOYS

Campaign to stop toys being promoted as only suitable for girls or boys.

[lettoysbetoy.org.uk](https://lettoysbetoy.org.uk)



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Rachel Dove



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# THE SPICE OF LIFE

Curry is one of Britain's favourite foods... and it turns out it's actually pretty good for you. We look at the research that's unravelling how the chemicals in spices can boost memory, fight fat and more

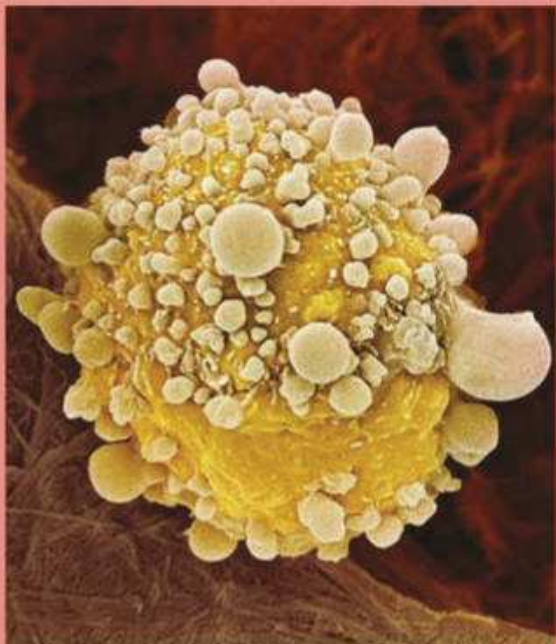
WORDS: EMMA DAVIES



“A month’s saffron treatment gave a boost to sexual function in women who had been treated for depression”

## GOOD FOR

- Mild depression
- Delaying cognitive decline
- Sexual function



TOP: It takes the stigmas of up to 165,000 saffron crocuses to produce 1kg of saffron

CENTRE: *Crocus sativa* is a cultigen – the species was created by human breeding and doesn’t grow in the wild

BOTTOM: Crocetin has been shown to inhibit the growth of pancreatic cancer cells in mice

# Saffron

Perhaps best known as the world’s most expensive spice, saffron has an alluring yellow colour and a subtly floral, slightly bitter taste. The golden strands are the dried stigmas (part of the female reproductive system) of *Crocus sativus* flowers. With a health-boosting reputation to match its price tag, saffron is packed full of antioxidants and many studies point to its cancer-fighting properties. It’s also said to be good for the brain. Some human studies suggest that taking 30mg per day may help to ease mild depression; others show that a daily dose may improve cognitive function in the early stages of Alzheimer’s disease. And that’s before we get to saffron’s famed aphrodisiac qualities, illustrated by an Iranian study showing that a month’s saffron treatment gave a boost to sexual function in women who had been treated for depression.

The spice contains hundreds of compounds, but its main biological components are safranal, crocin and picrocrocin, which deliver its aroma, colour and bitter taste. Of these, crocin and a related chemical called crocetin are largely responsible for its superpowers. Crocin has been shown to protect brain cells and act as an antidepressant, and also has a record of inhibiting tumour growth for a range of cancers in rodents, including breast and prostate.

At United Arab Emirates University, Dr Amr Amin’s team claims to have developed a method for treating cancerous liver cells using magnetite (iron) particles coated with crocin. “Our group provided evidence that saffron exerts a significant chemopreventative effect against both liver and colorectal cancer through different molecular mechanisms,” he says. Meanwhile, scientists at the University of Kansas suggest that crocetin can inhibit pancreatic cancer cells, both in a petri dish and in mice. The team recently made crocetin acid, which appears to have even more potent cancer-fighting abilities.

## Try it!

Studies recommend a daily dose of 30mg. Enthusiasts often opt for a simple tea, which can be repeatedly topped up with hot water until the threads have released all of their goodness.



# Turmeric

**T**his earthy, golden spice comes from the root of a plant in the ginger family and is the main ingredient in curry powder.

Turmeric has been used for medicinal purposes for nearly 4,000 years and is billed as being able to cure a dazzling array of ailments, from arthritis to erectile dysfunction, largely thanks to its main ingredient, curcumin.

But most clinical trials featuring humans have not shown clear benefits from consuming turmeric. Curcumin is difficult to study because it is not terribly stable and does not dissolve easily in water, which means it cannot be used by the body. In fact, research suggests that most curcumin is likely to travel straight through the digestive system, without being absorbed. Pharmaceutical researchers often refer to curcumin as a 'false lead' because it looks amazing on paper but is ineffective in reality.

The key lies in adapting the structure of curcumin, or attaching it to a chemical transporter. In 2011, stroke researchers at the Cedars-Sinai Medical Center, US, found that an adapted curcumin structure was able to repair stroke damage in rabbits. At the University of Illinois, a team of researchers have found a way to smuggle curcumin to targets in the body using platinum-based

compounds. The result is a complex that appears to be effective at treating various cancers, including melanoma and breast cancer.

Similarly, in lab tests at the University of Florida, scientists have attached curcumin to nanoparticles to destroy cells from neuroblastoma, a cancer that is most commonly diagnosed in children. The research suggests that the nanoparticles kill the cancer cells, although more study is needed to discover if the treatment would work in humans.

There is also evidence that curcumin can help with memory problems. A team at the University of California, Los Angeles, selected a widely available curcumin supplement called theracurmin for their study on 40 adults with mild memory complaints. Participants took a placebo or 90 milligrams of theracurmin twice daily for 18 months. The supplement gave the participants a significant memory boost, while PET scans showed lower levels of protein plaques in their brain. "We think that the anti-inflammatory effects

of curcumin may be protecting the brain," explains lead researcher Dr Gary Small.

"We are currently in the planning stage for our next study, which will attempt to replicate these findings and determine if curcumin's mood-elevating effects contribute to the cognitive benefits."

## Try it!

You probably need to consume at least one teaspoon per day. Try a turmeric shot, made palatable by adding fruit juice or coconut water. Or you could opt for a turmeric extract or supplement.

## GOOD FOR

- Arthritis
- Memory complaints
- Inflammation



TOP: Turmeric is the root of a plant in the ginger family

CENTRE: The amyloid-beta protein is the primary component of the brain plaques that cause Alzheimer's disease

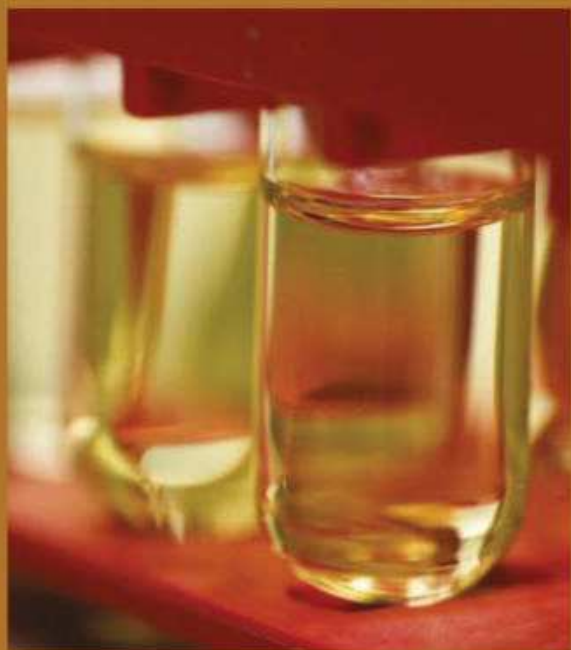
BOTTOM: Brain cell of an Alzheimer's patient, showing a characteristic tau protein 'tangle'



*“Research suggests that cinnamaldehyde may act directly on fat cells, inducing them to start burning energy”*

## GOOD FOR

- Flatulence
- Memory and learning
- Fat loss



TOP: Cinnamon is made from the bark of trees in the genus *Cinnamomum* – primarily the species *C. verum* and *C. cassia*

CENTRE: *C. cassia* oil has been proven to kill some strains of *E. coli* bacteria

BOTTOM: Coumarin crystals can cause liver damage – and cinnamon is often full of them

# Cinnamon

**T**his aromatic tree bark is used in a dazzling array of sweet and savoury dishes. It tastes great and has long been used in traditional medicine, particularly for treating flatulence and digestive imbalance.

Research suggests that a common form of cinnamon, called cassia, may lower blood glucose levels in people with type 2 diabetes. Although the results have yet to be confirmed, a small study at Raabe College of Pharmacy at Ohio Northern University recently showed that the cassia species of cinnamon is more effective at lowering blood glucose levels than diet alone. Amy Stockert and her team suggest that chemicals in cinnamon may bind to an enzyme in the insulin-signalling pathway.

Cinnamon's appealing aroma and flavour come mainly from a chemical called cinnamaldehyde, which has antibacterial and anti-fungal properties. Some research suggests that the substance may help to protect against obesity, though perhaps not when consumed in cinnamon pastries. At the University of Michigan, research in humans suggests that cinnamaldehyde may act directly on fat cells, inducing them to start burning energy. The chemical increased expression of several genes and enzymes that enhance lipid metabolism.

There is also evidence that cinnamon may have brain boosting properties. A study at Rush University Medical Center in Chicago, US, found that cinnamon appeared to help mice to learn, if their ability to navigate a complex maze is anything to go by. The cinnamon increased levels of a protein involved in memory and learning called CREB. The researchers point out that the body metabolises cinnamon to form sodium benzoate, commonly used as a chemical treatment for brain injuries. But think twice before you ingest vast quantities of cinnamon: it can contain high concentrations of a substance called coumarin, which can cause liver damage.

## Try it!

Cassia cinnamon is moderately toxic to the liver and kidneys, so you'd be better advised to opt for Ceylon cinnamon. Add it to your favourite curries and dessert dishes.



# Chillies

**C**hilli peppers originated in Mexico over 6,000 years ago but spread around the globe after Columbus got his hands on them. They get their spicy heat from capsaicin and a group of related chemicals called capsaicinoids. Extracted capsaicin is odourless and colourless, but its fiery punch is fierce: it's the main active ingredient in pepper spray. But it's also used as a pain reliever in many topical ointments, nasal sprays and dermal patches, and capsaicin creams have been proven to be effective for treating osteoarthritis pain.

Capsaicin depletes levels of the neuropeptide Substance P, which plays a key role in transmitting pain signals to the brain, as well as activating inflammatory chemicals in joints. In 2015, a team from the Chinese Academy of Medical Sciences tracked the health of nearly half a million people over several years. Those who ate chilli-rich food once or twice a week had a lower mortality rate than those who abstained, and daily chilli consumers had an even better chance of survival. It's not known quite why this is the case, but further analysis of data from the China Health and Nutrition survey suggests that higher consumption of chillies is also linked to lower levels of obesity. Meanwhile, a recent

Australian study suggests that chilli-eaters are less likely to have high blood pressure. Capsaicin relaxes blood vessels by increasing production of nitric oxide, which protects against inflammation.

Then there's the potential to fight cancer. Recent evidence suggests capsaicin may help to prevent certain cancers forming and to stop tumours growing. For example, capsaicin is thought to be able to kill prostate cancer cells. Indian researchers carrying out lab tests found that the compound binds to a cell's surface, causing membranes to rupture. There are also suggestions that chilli may help to prevent cancers from metastasising. But clinical development of capsaicin as an anti-cancer drug is limited due to side effects such as a burning sensation, stomach cramps and nausea. US scientists have got around this by making slightly different, more potent versions of capsaicin that retain the biological activity but not the heat.

Even in terms of basic nutrition, chillies have high levels of vitamins A and C.

All the more reason to eat lots of curries! If you're not a big chilli fan, bear in mind that the pain you feel when capsaicinoids bind to heat-receptor proteins in the mouth will fade the more regularly you eat it, as those receptors become desensitised, so you'll soon be able to handle hotter and hotter varieties.

## Try it!

Some fanatics suggest adding chilli to all main meals – and why not? If you have a sensitive stomach, dried chillies may be gentler. If you're not a heat freak, go for green chillies, which tend to be cooler but still deliver a powerful punch of the all-important capsaicin.

## GOOD FOR

- Pain relief
- High blood pressure
- Maintaining a healthy weight



TOP: Chilli peppers originally came from Mexico but now grow all over the world

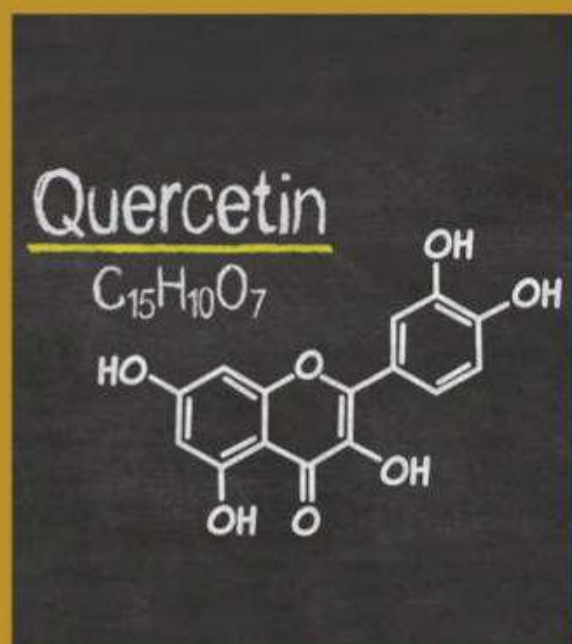
CENTRE: Capsaicin, the ingredient that gives chilli peppers their heat, is also a natural pain-reliever

BOTTOM: A woman drying out the chilli crop in China's Xinjiang province



## GOOD FOR

- Nausea
- Type 2 diabetes
- Arthritis



TOP: Ginger's medicinal properties have been known for millennia

CENTRE: The roots of a ginger plant, seen under a scanning electron microscope

BOTTOM: A molecule of the flavonoid quercetin, which can be used as part of an anti-diabetic treatment

## Ginger

**T**his instantly recognisable gnarly root comes from the same botanical family as turmeric and has been used as far back as the 4th Century BC for stomach ache, nausea and diarrhoea. Legend has it that the Ancient Greeks used it to combat nausea after the excesses of an orgy.

Ginger is generally soothing and satisfying. Its power to cure nausea means it is regularly prescribed to pregnant women without fear of side effects. Meanwhile, it's also reputed to be able to help fight cancer, though most tests so far have been carried out on isolated cells rather than in animals. Perhaps less important but more reassuring is the little-known fact that ginger promotes sweating – it is a so-called 'diaphoretic' – so it makes us feel warm, especially when we're feeling under the weather.

Ginger's ability to relieve nausea, arthritis and pain are generally attributed to aptly named chemicals called gingerols. A couple of these, 6-gingerol and 10-gingerol, are currently being investigated to prevent and treat cancer. It can lower blood glucose levels, and recent animal studies have homed in on 6-gingerol to help protect against type 2 diabetes.

One study on mice with the disease, for instance, showed that 6-gingerol increased insulin levels. Japanese tests on rats suggest that the chemical has anti-diabetic potential through a range of different mechanisms. They found that it can affect genes related to glucose metabolism and suggest that it could be used to treat as well as prevent type 2 diabetes. Combining 6-gingerol with a bitter chemical called quercetin, found in red onion and kale but also available as a supplement, significantly boosts the anti-diabetic effects, scientists from Nanchang in China have found.

And that's not all. Heating ginger causes substances called shogaols to form, giving the dried spice its characteristic pungent taste and aroma. The most common is 6-shogaol, which is currently causing much excitement in research circles, with studies suggesting that it can protect the brain and possibly help to fight cancer. For example, a 2015 laboratory study in India revealed that 6-shogaol may be better than conventional chemotherapy. Other studies suggest that 6-shogaol may help to fight gastric, colon, and colorectal cancer.

## Try it!

Ginger can be used fresh or dried and powdered, and studies suggest that as little as 2g of ginger per day may be enough to lower blood sugar. Ginger biscuit, anyone?

**Dr Emma Davies** is a science journalist with a background in food chemistry.



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Suicide is the biggest killer of men under 50. We want to know  
if current research could help us find a solution...

# CAN WE STOP MALE SUICIDE?

WORDS: SIMON CROMPTON

## WATCH THIS



Watch an episode of  
*Horizon* about male suicide  
on iPlayer. Available until  
21 September.





**T**here are myriad stories. People who were laughing an hour before they took their lives. People who were simply “not quite themselves”. People who had struggled with long-term depression. People who had a history of suicide in the family. Successful people who seemed to have everything to live for.

They all decided to kill themselves. Official records say that in the UK in 2016, 4,508 men and 1,457 women died as a result of suicide, but some experts believe the true numbers may be as high as double that. Men appear particularly vulnerable: in fact, suicide is the leading cause of death in men under 50 in the UK, claiming more lives than car accidents, heart disease or cancer. If it were a new disease, suicide would surely prompt a national emergency.

The reasons so many men take their lives are mysterious and infinitely diverse – a complex web of social, psychological, biological and cultural pressures. But new scientific approaches are presenting unexpected avenues for disentangling the threads. Virtual reality experiments and artificial intelligence are revealing those most at risk and could even predict who is most likely to try and take their life. Meanwhile, theories of male ‘social perfectionism’ are throwing light on why men feel they have failed. Together, they offer the prospect of better prevention. ●



● According to Prof Rory O'Connor, who runs the Suicidal Behaviour Research Lab at the University of Glasgow, changes in society are making men especially prone to the feelings of entrapment that seem to be a key driver to suicide as a means of escape. His lab works with suicide survivors in hospitals and other settings, and conducts studies in the lab to find links between suicide and psychological and social characteristics.

Some recent work, for example, has examined pain sensitivity. There is already some evidence that one of the reasons more men kill themselves than women is simply that they carry it through more effectively, using more lethal means. Working with men and women who had attempted suicide in a hostel setting, O'Connor's research supports this view. He found that men were less fearful about dying than women, and that men have greater ability to withstand the physical pain required to carry out more lethal methods of suicide.

"There are many things in the mix," says O'Connor. He points out that whereas in the 1990s men in their 20s were the highest suicide risk group, they have carried their vulnerability with them as they got older, so now it's men aged 40-50 who are highest risk. There's evidence that this is linked with recent changes to male identity in society. "Traditionally the male was the breadwinner, provided for the family, and was defined by this 'job for life' idea. This has changed markedly in recent decades, and men are still struggling with that," he says.

In particular, men may be struggling with something that O'Connor describes as "socially prescribed perfectionism". O'Connor's theory is that some men – the social perfectionists – are acutely aware of what they think other people expect of them, whether that be in work, family or other responsibilities. Men's social perfectionism can be judged using questionnaires asking how far they

# “It’s a myth, says men’s suicide charity CALM, that men don’t want to talk about their feelings”

agree with statements such as “Success means that I must work even harder to please others” and “People expect nothing less than perfection from me.” O'Connor has found a relationship between social perfectionism and suicidality in a wide variety of populations, from the disadvantaged to the affluent.

“According to my model, those who are highly aware of people’s social expectations are much more sensitive to signals of defeat in the world around them,” he says. “When things go wrong in their lives – for example, if they lose a job, a relationship breaks up or they become ill – they are much more affected by that.”

Proving such links is not easy. As O'Connor says, although devastating, suicide is statistically-speaking a rare event – so capturing what leads to it through conventional research requires many thousands of people. But US psychologist Dr Joe Franklin, who heads the Technology and Psychopathology Lab at Florida State University, believes he may have found an answer to this problem. He is rejecting conventional scientific research techniques, and instead probing the causes of suicide using virtual reality and a form of artificial intelligence called machine learning.

## HOW TECHNOLOGY CAN HELP

“In experiments, you can’t – for example – socially reject people to see whether that makes them more likely to kill themselves,” says Franklin. “But now we can give [subjects] the opportunity to engage in virtual suicidal behaviours, using virtual reality, and study this in the lab.”

For example, Franklin’s team is interested in testing a proposed link between social isolation and suicide which has until now been unproved. First, they exposed their test subjects to standard psychological scenarios designed to make them feel mildly socially rejected. Then they put them into virtual reality helmets, placing them in a scenario where they were standing on top of a high building.

“We said to them: ‘Okay, in order to finish the task, you can either step off the side of the building, or you can press the elevator button and ride down to the ground floor. Your choice,’” he says. Sure



LEFT: Dr Joe Franklin is using virtual reality to find out more about causes of suicide



# SUICIDE STATISTICS

**Among men aged 20-34, suicides account for 23.9 per cent of deaths**  
(England and Wales)

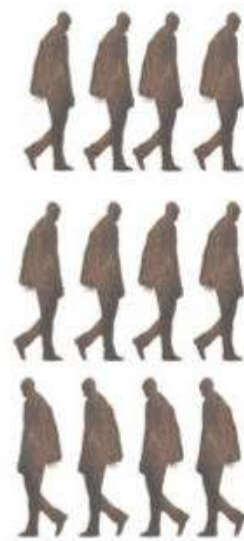
**Among men aged 35-49, suicides account for 11.3 per cent of deaths**  
(England and Wales)

**Suicide accounts for 20.5 per cent of deaths in the 20-49 age group for men and women**  
(England and Wales)

**4,508 male suicides in 2016**  
**1,457 female suicides in 2016**  
(UK)

**Divorced men are almost three times as likely to end their lives as men who are married or in civil partnerships**  
(England and Wales)

**770 THOUSAND**  
**people expressed suicidal feelings to Samaritans in 2016** (UK and ROI)



**45%**  
**of trans young people have tried to take their lives**  
(UK)

**12 MEN**  
**kill themselves every day** (UK)

**878**  
**male students took their lives between 2001 and 2017**  
(England and Wales)



enough, some of those who had been socially rejected chose to jump.

Franklin says there's now good evidence that this kind of experiment provides a good 'proxy' for real suicide attempts, so it has genuine value in studying many contributing causes of suicide. There are potentially thousands of factors that might contribute at least a bit – and each could be important, because Franklin's team has concluded there are no 'big' factors can accurately predict risk. However, the human brain is incapable of finding patterns in such complexity of causes, believes Franklin. The only way of getting to the root of suicide causes is by using machine learning.

"You give the machine every bit of information you have," he explains. "You say: we have these 500 people who died of suicide, and these 500 who didn't. Here's 2,000 bits of information about them all. Now you sort out the best algorithm for pulling those groups apart." This system could be potentially plugged into national electronic health records, both to find patterns of contributors to suicide and to identify individuals' suicide risk.

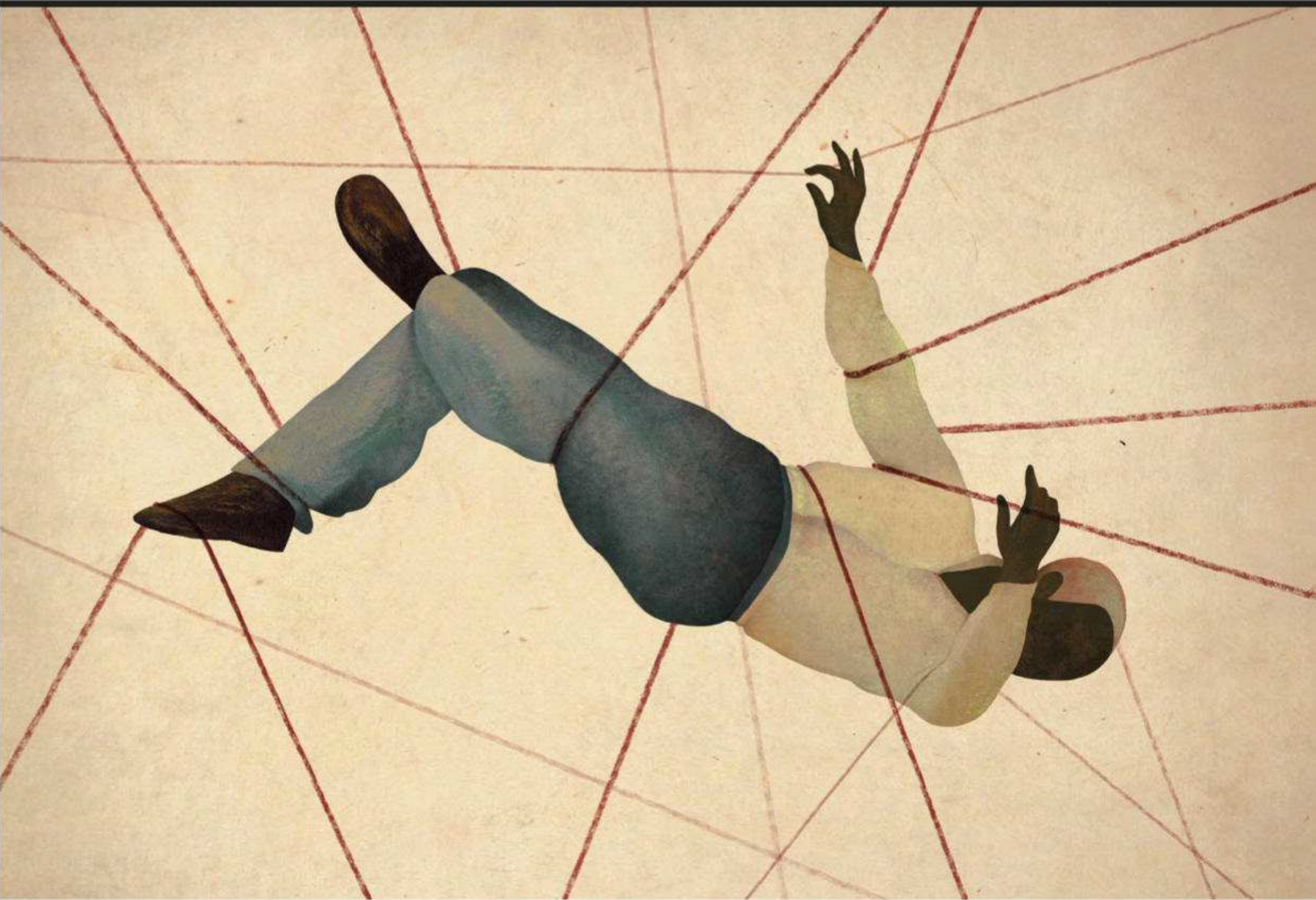
Amid the complexity, the data from virtual reality experiments and machine learning is likely to reveal psychological 'choke points', says Franklin, where preventative action may work on many fronts. One possible choke point his lab is currently testing is

the idea of psychologically tricking people into believing they are not suicidal.

"Our data so far indicates that how you conceptualise yourself is important: if you *believe* you are suicidal, you are more likely to engage in suicidal behaviours. So say I gave you a pill that was actually a sugar pill, but I told you one of its side effects was that it made people less likely to engage in suicidal behaviours," he says. "Then I tell you that's particularly true for people whose pain sensitivity goes down after taking it. Then I trick you into thinking that your pain sensitivity has gone down. What would very likely happen is that you would stop believing that suicide was an option for you. We know the placebo effect is pretty incredible, and if we could just flip that conceptual switch, maybe you'd get a quick and powerful intervention."

There's already evidence about the effectiveness of some public health choke point initiatives, effectively making suicide more difficult to perform. Firearm suicide rates in Australia fell by 57 per cent in the seven years after a gun ban in 1997, and the number of paracetamol overdoses in the UK dropped significantly when a limit was placed on the number of tablets each customer was permitted to buy (anecdotally, the extra effort required to remove a large number of tablets from the





SUICIDE'S COMPLEX WEB

A background of stressful life events may predispose people to suicidal thoughts. Some other factors that may contribute to people becoming suicidal are:

1 Mental health problems

Around 90 per cent of those who take their own lives have experienced a mental illness, most commonly depression. However, the overwhelming majority of people with depression don't kill themselves.

2 Physical health problems

Nearly all physical health problems are associated with increased suicide risk. Suicide is twice as prevalent among those who have cancer as those in the general population, and men with cancers that affect the genito-urinary system, such as prostate cancer, may be five times more likely to take their own lives.

3 Unhappy relationships

Research shows a link between relationship breakdown and suicide risk. According to Samaritans, divorce is more likely to lead men, rather than women, to suicide. But research at the Medical University of Vienna suggests those in unhappy relationships may be at even greater risk.

4 Austerity

Evidence of the link between financial worries and suicide has been strengthened by new research indicating that suicides in young men rise notably in countries suffering from economic crisis where job losses are high. One study found that every 1 per cent fall in GDP growth sees a 0.9 per cent rise in suicide rates.

5 Screen time

The more time teenagers spend on smartphones and other electronic screens, the more likely they are to feel depressed and think about suicide, according to a new study from the University of Florida. People under 25 who are victims of cyberbullying have been reported to be twice as likely to self-harm and have suicidal behaviours.

6 Availability of lethal means

Availability of guns is particularly important in determining male rates of suicide in the United States: a new study shows that gun ownership explains 71 per cent of the variations in male suicide rates from state to state.



• now-compulsory blister packs may also have been a factor).

In Detroit, USA, the Henry Ford Health System has reduced suicide rates by 80 per cent among service users diagnosed with depression, achieving its aim of zero suicides in 2009. Its model involves improving access to care, restricting access to lethal means of suicide such as guns, and holding staff accountable for learning and improving after each suicide. Health systems around the world are now using the Henry Ford approach as a model to reduce suicides among mental health patients.

### REACHING OUT

O'Connor believes such large-scale public health approaches are important, but says if the male suicide problem is to be properly tackled, there need to be gender-specific initiatives. "We need to speak to men and genuinely understand what they need. That involves getting beyond referring men to clinical services, but going to where men are – sports clubs, for example – and promoting connection, wellbeing and stress management there, though not framed as 'suicide prevention'."


It's a myth, says men's suicide charity CALM, that men don't want to talk about their feelings – they often simply don't want to share their problems with family, friends and colleagues. That's where confidential and anonymous helplines such as Samaritans and CALM have a vital role to play.

BELOW:  
Following the  
National  
Firearms  
Buyback  
Program in  
Australia, more  
than 660,000  
guns were taken  
out of public  
hands, and  
suicide by  
firearms  
decreased  
dramatically



Clinical psychologist Martin Seager, formerly a consultant for Samaritans, agrees it's important to target services specifically to men, and advocates men-only discussion groups across the country. "In single-sex groups men can be very bloke-y one minute, then talk about something incredibly painful the next. If men are alone in a room they are tremendously good at supporting each other."

Another way of helping men explore their feelings without involving those close to them is via technology. Franklin's team has developed an experimental mobile app that increases aversion to suicide and promotes feelings of self-worth via a simple association game available on iOS called *Tec-Tec*. Early trials are encouraging. Another American psychologist, Robert Morris, is trialling a website which provides peer support for people with depression and helps users reassess negative thoughts using cognitive behavioural therapy.

O'Connor is working with researchers at Vrije Universiteit Amsterdam on a smartphone app that will help high-risk men monitor feelings of entrapment and suicidality. He believes that technology undoubtedly has a role to play. "But we need to get evidence first," he says. "If we can demonstrate that an approach is effective in a clinical trial, then you can use an app-based approach to broaden its reach to everyone." 

**Simon Crompton** is a science journalist and former health editor for both *The Times* and *The Daily Telegraph*.

### DISCOVER MORE



Listen to an interview with Jesse Bering, author of *Suicidal: Why We Kill Ourselves*. Visit [sciencefocus.com/sciencefocuspodcast](https://sciencefocus.com/sciencefocuspodcast) or subscribe on iTunes, Acast, Stitcher, or your favourite podcast app.

## WHERE TO FIND HELP

If you are concerned about someone, talk to them and gently ask them if they're feeling suicidal. "It sounds scary, but there's no evidence that asking about suicide plants the idea in someone's head," says psychologist Rory O'Connor. "Indeed, there's some evidence that it protects people. Often the person who's suicidal feels relieved that someone has actually asked them the question."

### Talk to someone

Samaritans is a safe place for anyone to talk about difficult feelings, 24 hours a day. Phone free (UK/ROI) on 116 123 or email [jo@samaritans.org](mailto:jo@samaritans.org)

The CALM helpline is for men in the UK who need to talk or find information and support. Open 5pm-midnight. Phone free on 0800 58 58 58



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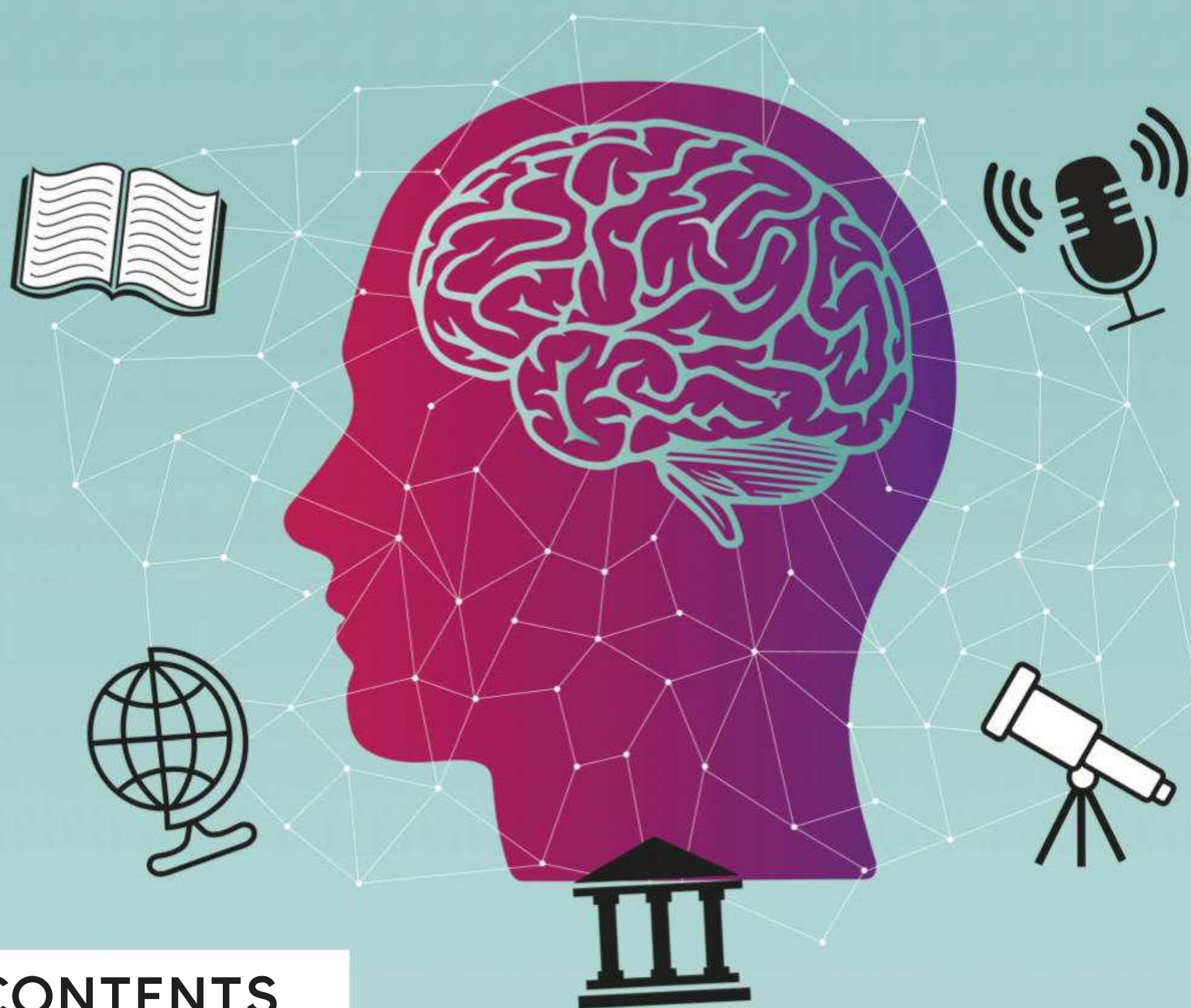
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# LIFE IS FOR LEARNING



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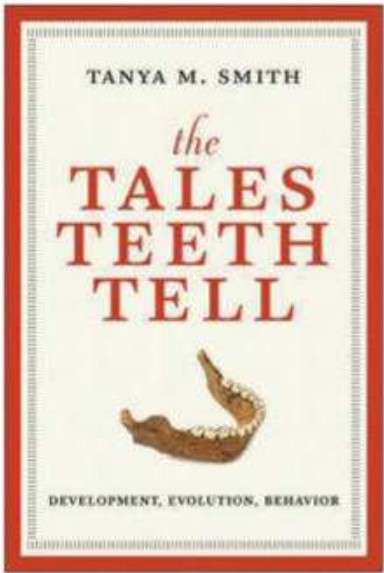
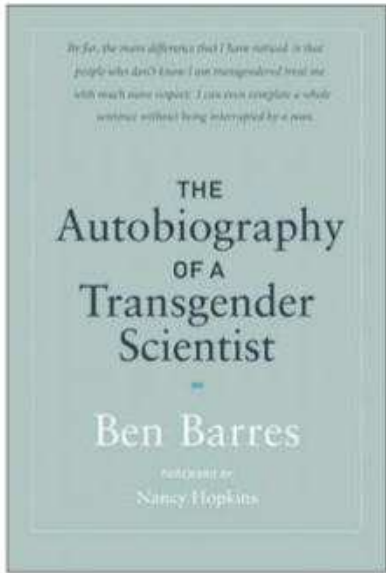
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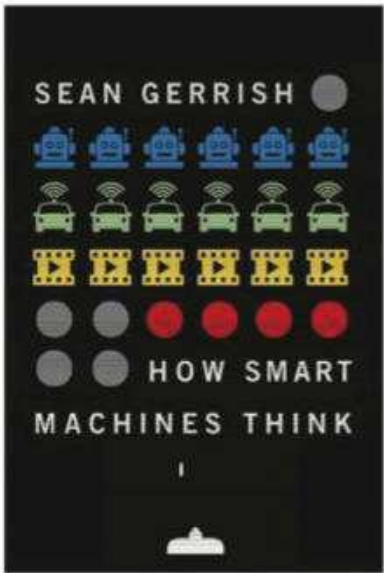
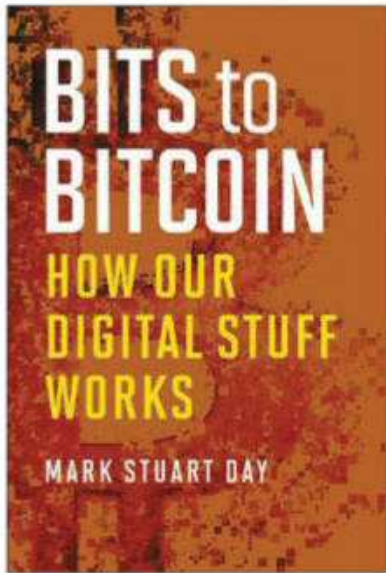
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Never be fooled into thinking science is just about studying. Science is about exploring, experimenting and wondering why. It's standing on a hilltop on a clear night, staring at the sky. It's dunking three different types of biscuit in your tea to find out which gets the soggiest. It's asking: why do I dream? If you're the curious type, science, technology, engineering and maths (STEM) might offer a way forward in your career. As the scientists and engineers we've featured in our 'Incredible science careers' section show, you can do so much more with a STEM qualification than just pore over academic papers. Of course, if your interests have already led you elsewhere, you can still indulge a passion for discovery, even without a degree in science. Check out our listings for some of the most inspiring talks, events, apps and podcasts for everyone from the aspiring surgeon to the armchair philosopher. And best of all, you can even enjoy some of these on your lunchbreak. Science with your sandwich – sounds great to us!





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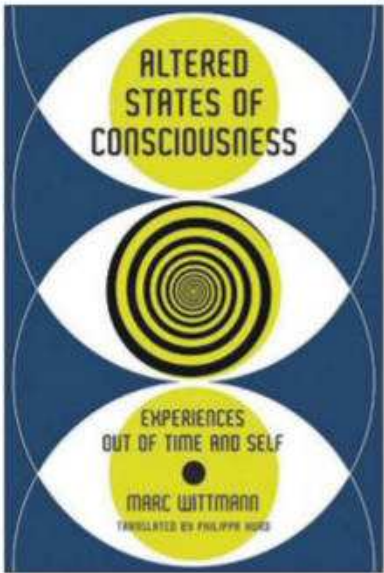
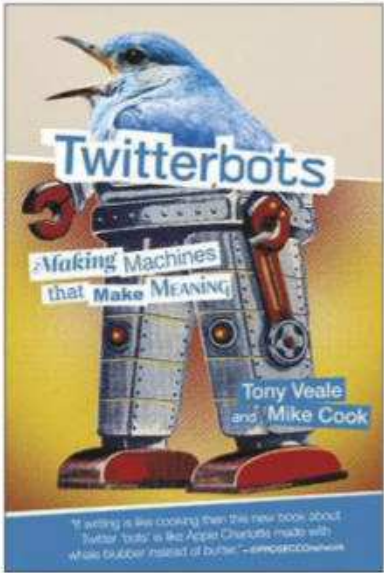
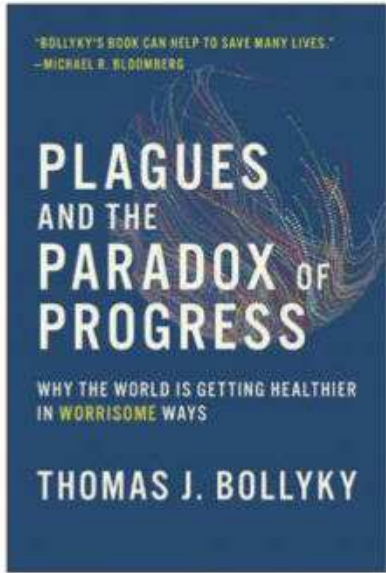
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# INCREDIBLE SCIENCE CAREERS

Think science is all about wearing a white coat? Think again...



## Dr Alice Gregory (below)

Psychologist

Goldsmiths, University of London



### I studied...

Experimental psychology at the University of Oxford, then social, genetic and developmental psychiatry at King's College, London.

### I got into science because...

As a child, I lost the tip of a finger in a door and part of my toe was grafted onto the end of my finger. The procedure seemed miraculous and possibly kick-started my fascination with the human body, mind and behaviour.

### A typical week at work involves...

Recently, I've been catching up with progress on a sleep research project and working with a journalist on a piece about

my new book *Nodding Off*. Today, I fly to Borneo to give a lecture on sleep.

### The best thing about my job is...

It's a privilege to contribute to scientific knowledge even in a small way, but perhaps more significantly I've enjoyed supervising others who will likely go on to make important contributions.

### On my bookshelf...

*I, Mammal* by Liam Drew

*Science And The City* by Laurie Winkles

*Neurotribes* by Steve Siberman

### My favourite websites...

Technology Networks

[technologynetworks.com](http://technologynetworks.com)

IFL Science [iflscience.com](http://iflscience.com)

The *BBC Focus* podcast!

[sciencefocus.com/sciencefocuspodcast](http://sciencefocus.com/sciencefocuspodcast)

### A typical week at work involves...

In the spring and summer, I'm usually in the field looking for new dinosaurs. During the autumn, I teach every day at the University of Edinburgh and throughout the year I manage my lab and supervise students that study with me.

### The best thing about my job is...

Every day is so different and each day I have the chance to learn something totally new about the world.

### On my bookshelf...

*The Dinosaur Heresies* by Robert T Bakker

*The Ends Of The World* by Peter Brannen

*The Dinosaur Artist* by Paige Williams

## Dr Steve Brusatte (right)

Palaeontologist

University of Edinburgh

### I studied...

Geophysical sciences at the University of Chicago. My PhD was in vertebrate palaeontology at Columbia University of New York.

### I got into science because...

My youngest brother Chris was obsessed with dinosaurs and it was through him that I slowly, through osmosis, got into dinosaurs, fossils, evolution and science.





**My favourite websites...**

The New York Times [nytimes.com](http://nytimes.com)  
 Washington Post [washingtonpost.com](http://washingtonpost.com)  
 The Atlantic [theatlantic.com](http://theatlantic.com)

**Helen Arney**

Science presenter

**I studied...**

Physics at Imperial College London. More recently, screenwriting at City University.

**I got into science because...**

I had great physics and maths teachers and was inspired by physicist Richard Feynman's books, which I read under the duvet with a torch, age 12.

**A typical week at work involves...**

Right now I'm producing our third Festival Of The Spoken Nerd show for DVD and download *You Can't Polish A Nerd*. We wrote the script and songs last year and recorded it in June, so my summer is all about video edits and admin. So much admin!

**The best thing about my job is...**

I make my own work, manage my own schedule and juggle the time I spend with my gorgeous toddler. See also: worst thing about my job.

**On my bookshelf...**

*Surely You're Joking, Mr Feynman!* by Richard P Feynman  
*The Immortal Life Of Henrietta Lacks* by Rebecca Skloot  
*This Is Going To Hurt* by Adam Kay

**My favourite websites...**

Ed Yong [edyong.me](http://edyong.me)  
 Twisted Doodle [twisteddoodles.com](http://twisteddoodles.com)  
 Story Collider [storycollider.org](http://storycollider.org)

**Prof Brendan Walker (above right)**

Thrill engineer  
 Thrill Laboratory and Middlesex University

**I studied...**

Aeronautical engineering at Imperial College, then industrial design engineering at the Royal College of Art.

**I got into science because...**

After my degree, I spent some time working at British Aerospace in computational fluid dynamics and wind tunnel testing. This gave me a passion for bouncing between theoretical modelling and practical experimentation.

**A typical week at work involves...**

I create my own experimental rides and currently I'm working with virtual reality and movement so this means spending a lot of time touring work internationally to test it with a large audience.

**The best thing about my job is...**

I'm not constrained by the boundaries of disciplines. I enjoy moving freely between science, technology, art and design.

**On my bookshelf...**

*Handbook Of Psychophysiology* edited by John T Cacioppo  
*Understanding Pendulums: A Brief Introduction* by L P Pook  
*Prisoner's Dilemma* by William Poundstone

**My favourite websites...**

The Physics Hypertextbook [physics.info](http://physics.info)  
 The Game of Life [web.stanford.edu/~cdebs/GameOfLife/](http://web.stanford.edu/~cdebs/GameOfLife/)  
 Make Magazine [makezine.com/](http://makezine.com/)

**Rose Bailey (below)**

Greenhouse gas emissions expert  
 Ricardo Energy and Environment

**I studied...**

Human sciences at the University of Oxford and then environment and international development at the University of East Anglia. My PhD was in carbon management at the University of the West of England.

**I got into science because...**

I studied the wrong A-Levels for science! However, my undergraduate degree made me realise I wanted an environment-focused career that was also connected to policy and society.

**A typical week involves...**

A real mix! This week, for example, I've been crunching numbers on city emissions data, while preparing for a workshop next week in Ghana to train decision-makers on how to develop a climate action plan for their city.

**The best thing about my job is...**

The variety and working at the interface between science and policy.

**On my bookshelf...**

*Bad Science* by Ben Goldacre  
*Sustainable Energy Without The Hot Air* by David MacKay  
*The Selfish Gene* by Richard Dawkins

**My favourite websites...**

United Nations Climate Change [unfccc.int](http://unfccc.int)  
 The UK's Live Air Quality [uk-air.defra.gov.uk](http://uk-air.defra.gov.uk)  
 The Climate Action Tracker [climateactiontracker.org](http://climateactiontracker.org)



People Like Me is for girls ages 11-19 helping them find out where they could be happy and successful in careers in STEM.



Are you confident? Good with people? Creative? Practical? Logical?

Find out where people like you are happy and successful with...



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- PEC Astronomy – to GCSE standard but without the exam
- PEC Advanced Astronomy – for the more dedicated student

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Discover Europe's Oldest Operating Theatre (1822) housed in the attic of St Thomas' Church.



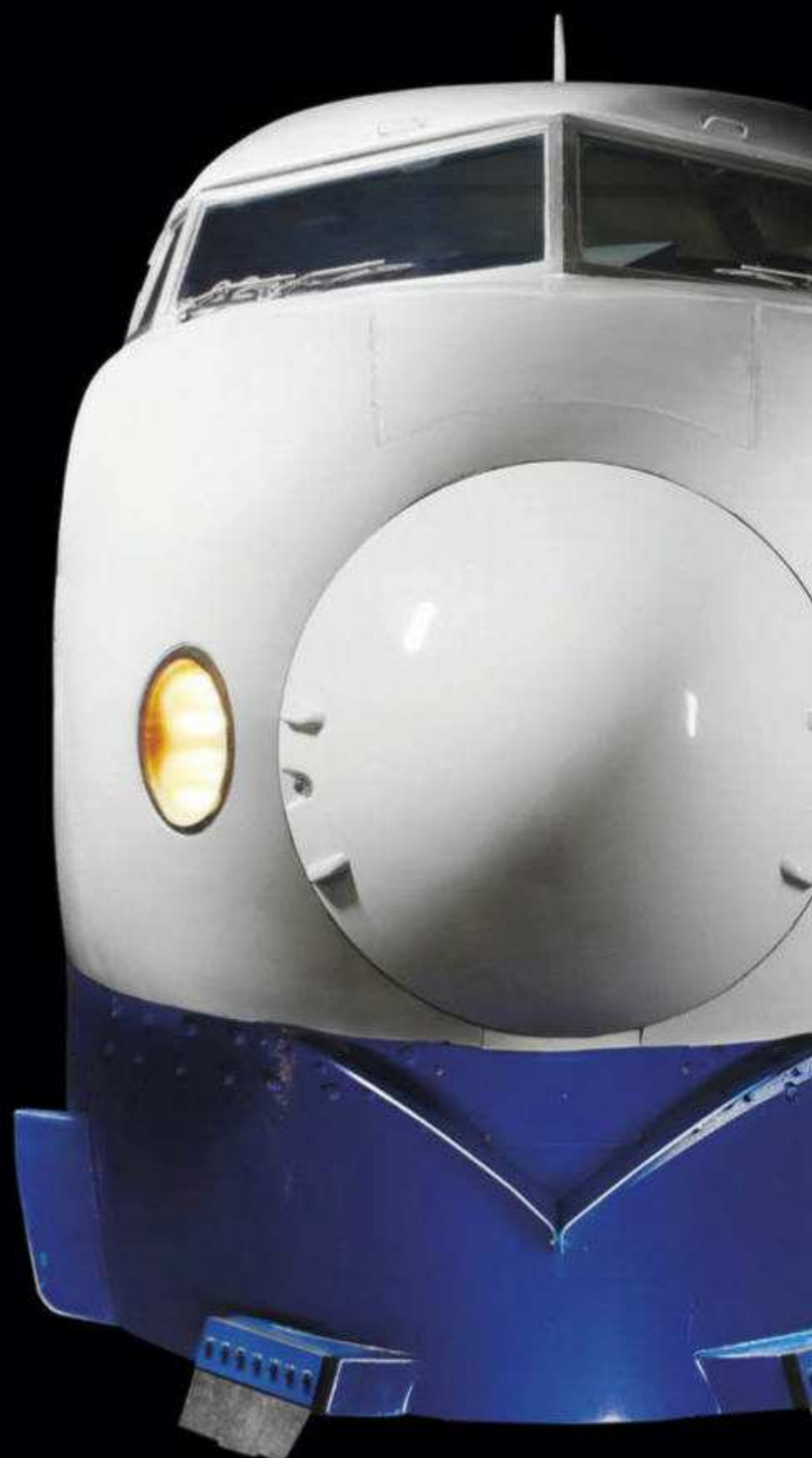
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Admission Charge



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# GET SMART THIS AUTUMN

Don't spend your free time bingeing on boxsets. Get that grey matter churning at one of these events

Current – 25 November

## The Impossible Garden

University of Bristol Botanic Garden, Bristol  
Mon-Sun, 10am-4:30pm,  
Adults £5.50 / Children free  
[bit.ly/impossible\\_garden](http://bit.ly/impossible_garden)



Open-air sculpture exhibition challenging our ideas about vision and perception. Developed by renowned artist Luke Jerram, following his residency at the Bristol Eye Hospital and Bristol Vision Institute.

3 October

## Blood, Sweat And Snakebites

University of Wolverhampton, Stafford. 6pm, Free.  
[bit.ly/blood\\_sweat\\_snakes](http://bit.ly/blood_sweat_snakes)



Meet reptile expert Mark O'Shea, who has worked on documentaries for Channel 4 and The Discovery Channel, as he tells tales of wildlife film-making and the scientific discoveries made along the way.

20 September

## After Hours Victorian Surgery Demonstration

The Old Operating Theatre Museum and Herb Garret, London  
7pm, £12  
[bit.ly/old\\_operation](http://bit.ly/old_operation)



What was surgery like before anaesthetics and antiseptics? Find out, as actors recreate a Victorian surgical procedure in a real 19th-Century operating theatre at St Thomas's Hospital.

5 October

## Summitting The Science Of Everest

Oxford Playhouse, Oxford.  
5pm, £7  
[bit.ly/science\\_everest](http://bit.ly/science_everest)



Join scientist and adventurer Melanie Windridge as she shares her experiences of summiting the world's tallest mountain and explains how science and technology contribute to feats of human endurance.

25 September – 21 October

## Life, Lines And Illusion

Nature in Art Gallery and Museum, Gloucester  
Tues-Sun, 10am-5pm  
Adults £5.25 / Children £4.75  
[bit.ly/nature-in-art](http://bit.ly/nature-in-art)

Nature-inspired exhibition featuring drawings and photographs by zoologist Hugh B Cott, who served as a camouflage expert for the British Army in WWII.

From 5 October

## Winter Public Astronomy Evenings

Royal Observatory, Edinburgh.  
6:30pm-7:30pm or 8-9pm  
Adults £5 / Children £4  
[bit.ly/public\\_astronomy](http://bit.ly/public_astronomy)



Wrap up warm for the Royal Observatory's Friday night astronomy session, including a tour of the Victorian telescope dome and stargazing outside on the roof. See website for selected winter dates. Suitable for all ages.

29 September

## Front-line: The Future Of Cancer

ThinkTank Centre, Birmingham  
7pm, Free  
[bit.ly/frontline-cancer](http://bit.ly/frontline-cancer)

Researchers share the latest advances in cancer treatments, including new gene editing and radiotherapy techniques. Plus, a chance to ask questions and hear patients talk about their own experiences.

15 October

## Wally Funk's Race For Space

National Space Centre, Leicester  
9am, Adults £15 / Children £12  
[bit.ly/wally\\_funk\\_space](http://bit.ly/wally_funk_space)

Join astronaut Wally Funk and science journalist Sue Nelson in this Q&A session. Although you'll need to pay separately for entry to the Space Centre, tickets include a breakfast burrito. What's not to like?



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NEWCASTLE Metro Radio Arena	08
MANCHESTER Arena	09
SHEFFIELD FlyDSA Arena	10
PETERBOROUGH Arena	13
LEEDS First Direct Arena	14
BELFAST SSE Arena	15
DUBLIN 3 Arena	16
GLASGOW The SSE Hydro	19
ABERDEEN AECC	20
LIVERPOOL Echo Arena	21
NOTTINGHAM Arena	22
BIRMINGHAM Arena Birmingham	23
LONDON The SSE Arena, Wembley	24
BRIGHTON Brighton Centre	26
BOURNEMOUTH International Centre	27
PLYMOUTH Pavilions	28

**MARCH**

CARDIFF Motorpoint Arena Cardiff	01
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# LEARN ON YOUR LUNCH

Aimlessly browsing the internet doesn't achieve anything. Make your lunchbreak work harder...

## Code with carrots



Grow your CSS coding skills with *Grid Garden*. This simple web-based game teaches you the language of web design via a virtual garden planted with carrots, which you'll need to weed and water. Progress through 28 levels.

🔗 [cssgridgarden.com/](http://cssgridgarden.com/)

## Solve puzzles



Play a crowdsourcing computer game and contribute to curing disease. *FoldIt* pits gamers against each other to fold the best proteins, helping scientists to solve the structures of molecules that are important in diseases such as cancer and HIV.

🔗 [fold.it/portal/](http://fold.it/portal/)

## Stare into space



Spot specks of interstellar dust in samples collected from a comet by the Stardust spacecraft. Scientists need your help to search through millions of microscope images taken at the Johnson Space Centre in Houston.

🔗 [stardustathome.ssl.berkeley.edu/](http://stardustathome.ssl.berkeley.edu/)

## Stay curious



The free *Curiosity* app delivers science in bite-sized chunks, in a variety of content formats, on a wide range of topics. Spend five minutes watching a video about quantum teleportation or trying to solve an ancient riddle, and still have time for lunch. For iPhone and Android.

🔗 [curiosity.com/app/](http://curiosity.com/app/)

## Study medicine



Download the app *Complete Anatomy* for 3D interactive models of the human body to explore and assemble via smartphone. Features 6,200 anatomical structures plus expert lectures. For iPhone and Android. Full version \$4.99.

🔗 [3d4medical.com/apps/complete-anatomy](http://3d4medical.com/apps/complete-anatomy)

## Get crafty



Improve your maths and your creativity at the same time with a free paper-folding course from FutureLearn, which teaches you how to make flexagons. It's like origami for geometry fans. Six hours over three weeks.

🔗 [futurelearn.com/courses/flexagons](http://futurelearn.com/courses/flexagons)

## Take a walk



Turn lunchtime into a nature walk by taking pictures of trees and adding them to *Treezilla's* interactive map. The aim is to map every tree in Britain.

🔗 [treezilla.org](http://treezilla.org)

## Our pick of the podcasts



Can't face anything too strenuous while you munch your lunch? Plug in, tune out, and get smarter.

### For space junkies...

#### The Habitat

Documentary following the lives of six fake astronauts on a fake mission to Mars, somewhere in Hawaii.

[gimletmedia.com/the-habitat](http://gimletmedia.com/the-habitat)

### For fact fans...

#### No Such Thing As A Fish

The research team behind BBC's *QI* shares the most interesting facts uncovered each week.

[qi.com/podcast/](http://qi.com/podcast/)

### For armchair philosophers...

#### Waking Up

Interviews exploring questions about the human mind and society through the lens of neuroscience.

[samharris.org/podcast/](http://samharris.org/podcast/)

### For futurists...

#### Level Up Human

Scientists and comedians bounce around ideas for the next stages of human evolution.

[leveluphuman.com/](http://leveluphuman.com/)

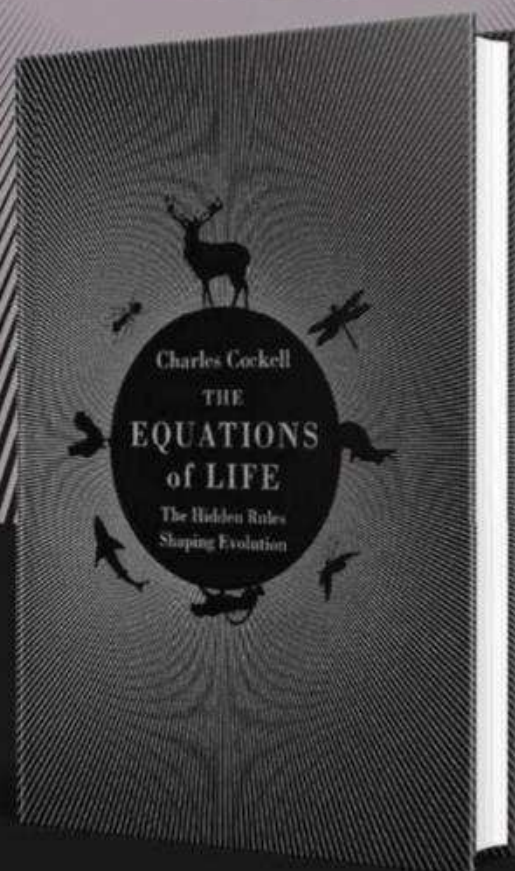


Why do gazelles have  
legs and not wheels?

Why is all life based on  
carbon rather than silicon?

Why do humans have eyes on  
the front of their heads?

The puzzles of life astound and confuse us like no other  
mystery. But in this ground-breaking account of the  
process of evolution, Professor Charles Cockell,  
Britain's foremost astrobiologist, reveals how  
nature is far more understandable and  
predictable than we think...



“Fascinating. A profound  
exploration of the deep nexus  
between physics and biology”

Andreas Wagner, author of *Arrival of the Fittest*

OUT  
NOW





# SECRET SCIENCE

Our insiders reveal some of the best hidden spots in our cities



## 1 Oxford

### Wytham Woods

Just outside the city lies Wytham Woods, which is a mix of semi-wild woodland and grassland that was given to the university over 60 years ago. You can apply for a permit to walk there, provided you don't disturb the experiments.

### Oxford University Museum Natural History, South Parks Road

Hidden at the back of the building is the Pitt Rivers Museum, which is crowded with fascinating items, including shrunken heads, a Hawaiian cloak made of red and yellow feathers, a lantern fashioned from a puffer fish, and a set of nested ivory balls, made from a single lump of ivory.

[prm.ox.ac.uk](http://prm.ox.ac.uk)

## 2 London

### John Snow pub, Broadwick Street

This Soho pub overlooks the memorial water pump that's dedicated to John Snow himself, who was an eminent 19th-Century physician and the father of public health.

### The Monument, Fish Street Hill

This commemorates the Great Fire of London of 1666. Scientists Christopher Wren and Robert Hooke designed this impressive column, which is also a giant scientific instrument. The central shaft is a zenith telescope. It sits atop an underground laboratory.

[themonument.org.uk](http://themonument.org.uk)

## 3 Bristol

### Clifton Rocks Railway, Sion Hill

This funicular railway is dug into the rocks beside the Avon Gorge. It ran from 1893 until 1934 carrying passengers between Clifton and Hotwells. In WWII, after its closure, it was a secret transmission base for the BBC. Occasionally, the site is open for public visits.

[cliftonrocksrailway.org.uk](http://cliftonrocksrailway.org.uk)

### Underfall Yard, Cumberland Road

A working boatyard with a number of maritime-related activities. It's a short walk away from Isambard Kingdom Brunel's passenger steamship, the *SS Great Britain*.

[underfallyard.co.uk](http://underfallyard.co.uk)

## 4 Dublin

### Broome Bridge

This bridge passes over the Royal Canal, and is reputedly where the Irish scientist Sir William Rowan Hamilton etched his mathematical formula into the stone. Apparently, he had a moment of inspiration and didn't want to forget it. It was the formula for what are now known as quaternions – used as the basis for 3D graphics in computer games.

### Natural History Museum

Known as the 'Dead Zoo' by locals, it's a treasure trove of creatures of all shapes and sizes. It opened one year before Darwin published *On The Origin Of Species*, and has some pieces that were actually collected by him.

[museum.ie/Natural-History](http://museum.ie/Natural-History)

## 5 Manchester

### Castlefield Canal Basin

This is an area that combines bars with hundreds of years of history – Roman remains, the Bridgewater Canal (1761) and three railway lines (one now a tramway). It's a stone's throw from the Museum of Science and Industry (MOSI).

### Manchester Museum

The university's museum includes exquisite fossils from the Cambrian Explosion and brilliant jewel beetles. It's close to Coupland Street, where Alan Turing worked in the last years of his life, where Peter Mark Roget (of the thesaurus fame) had a house, and where Ernest Rutherford, Hans Geiger and Ernest Marsden showed that atoms have internal structure in 1909.

[museum.manchester.ac.uk](http://museum.manchester.ac.uk)

## 6 Edinburgh

### Merchiston Tower, Colinton Road

John Napier, the father of logarithms, was a scientist from Edinburgh. His former home was Merchiston Tower.

### Macdonald Armouries, Brunswick Street Lane

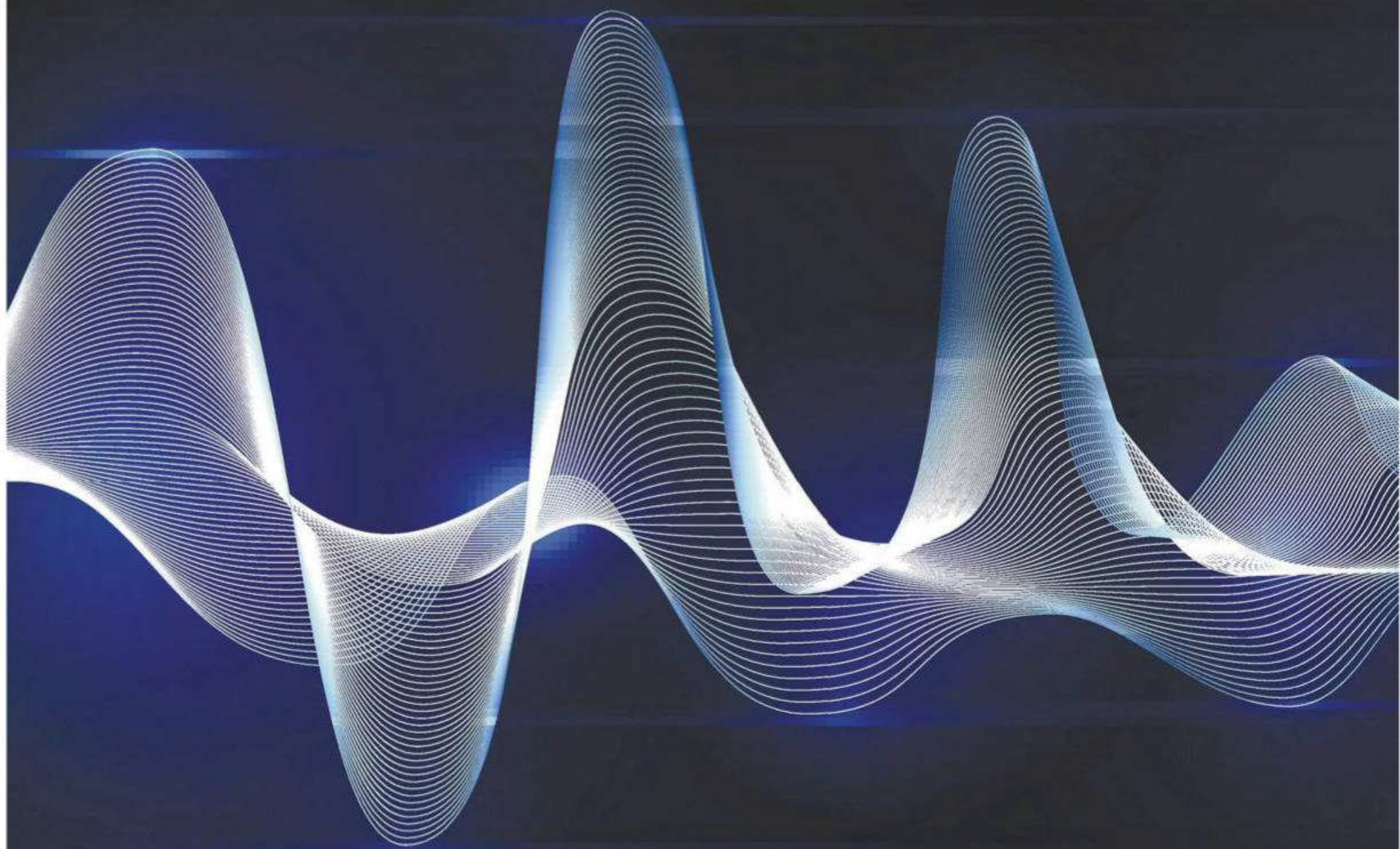
Macdonald Armouries recreates swords from different historical periods. It's a great mix of history, engineering and martial arts.

[macdonaldarms.com](http://macdonaldarms.com)



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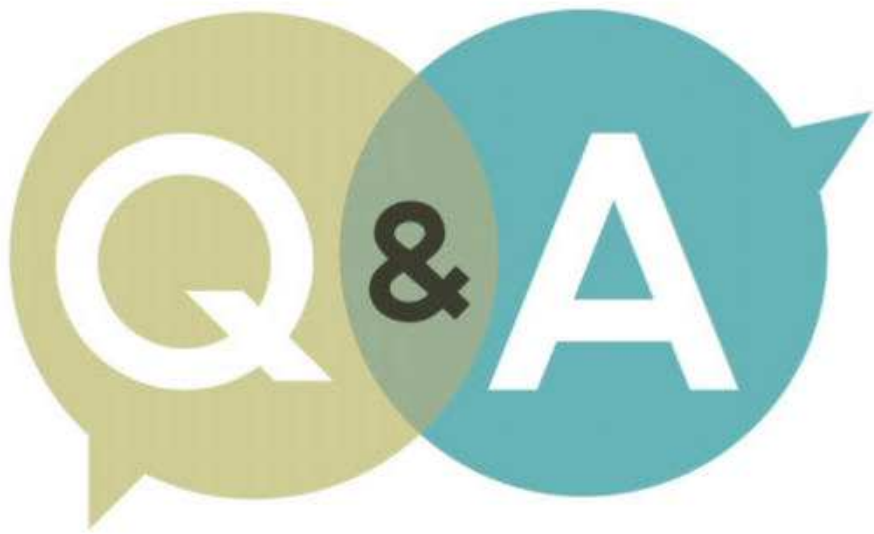


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Science/tech  
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**DR GILES YEO**  
Geneticist,  
food expert



**PROF ROBERT MATTHEWS**  
Physicist,  
science writer

# YOUR QUESTIONS ANSWERED

OCTOBER 2018

EDITED BY JAMES LLOYD

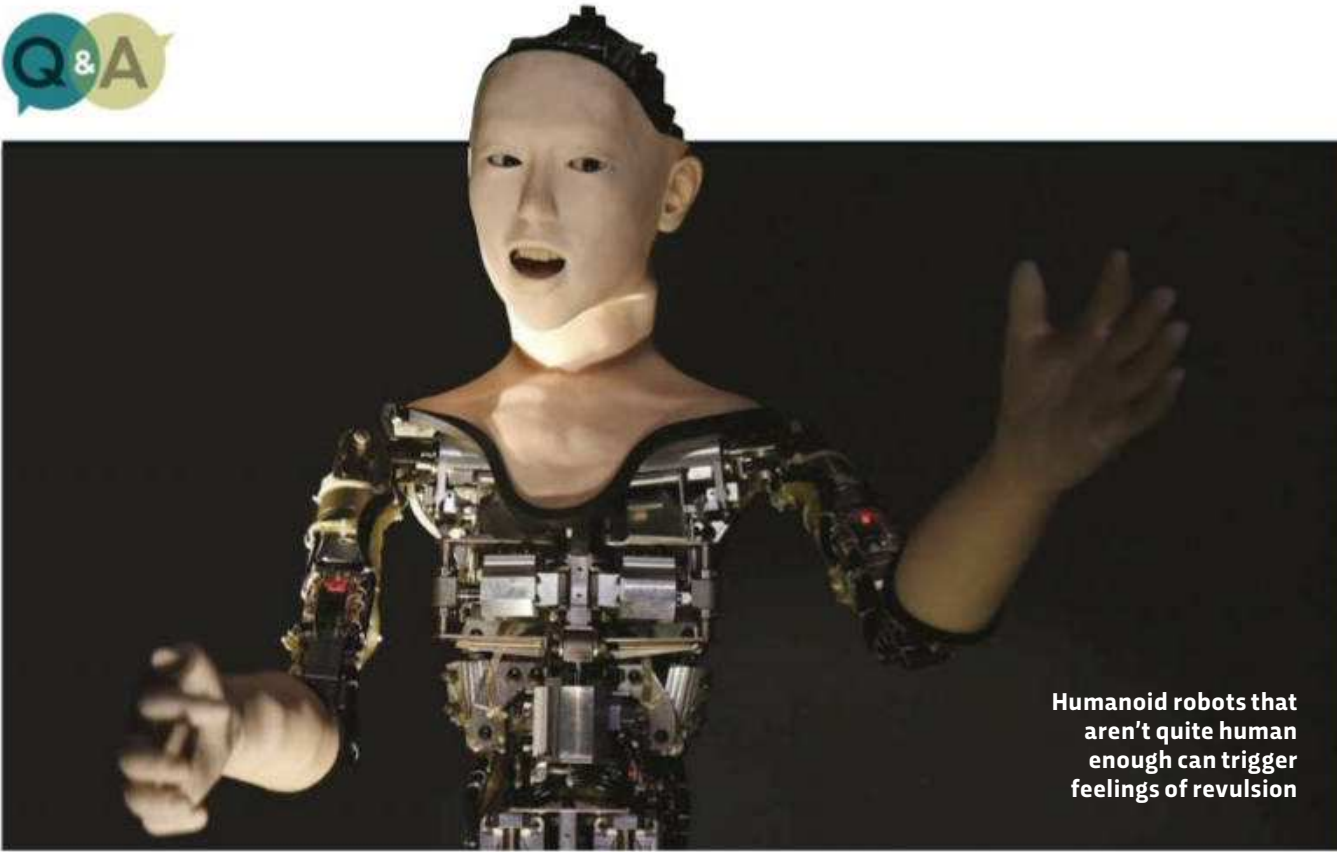
Why hasn't the  
amoeba evolved  
more? Because it  
doesn't need to...

**If life on Earth is constantly evolving, why do we still have life forms such as amoebas?**

TOM HAMPTON, TOWNSVILLE, AUSTRALIA

Evolution is not a ladder, with every organism steadily climbing its way to the top. It's a cacophony of random mutations where natural selection favours the ones that are slightly better adapted to their local environment. Amoebas are simpler organisms than humans or pine trees, but they aren't less evolved: they're the result of the same four billion years of evolution as every other living thing. Amoebas continue to exist because they're very well adapted to life in each of the many different ecological niches they've colonised, from the bottom of the sea to the inside of your skull. **lv**





Humanoid robots that aren't quite human enough can trigger feelings of revulsion

## Why do we make robots look like humans?

ROBERTA WILD, LINCOLN

We've always been fascinated by the idea of creating autonomous machines that resemble us, and if they need to interact closely with us, we prefer them to look familiar. Human-like robots such as Honda's ASIMO, Boston Dynamics' Atlas, and the childlike iCub built by the Italian Institute of Technology are amazing demonstrations of our technology, but they still have a long way to go – and when they look nearly human but not quite, they end up looking seriously freaky to us. Perhaps we should just let robots be the shape they need to be, in order to best carry out their function. **PB**



## Why are pigeons such a successful city bird?

JAMES MCKENZIE, LEIGHTON BUZZARD

Pigeons arose from the domestication of rock doves, as early as 10,000 years ago. Having originated from domestic stock, it's no surprise that the UK's estimated 18 million feral pigeons are inherently tolerant of humans. Happily living alongside us, these unfussy eaters will flock to areas where people feed them. The tall concrete buildings within our cities are perfect pigeon territory because they replicate the cliff faces which are still home to wild rock doves in Scotland and Northern Ireland. **cc**

## WHAT CONNECTS...

### ...7 UP AND BIPOLAR DISORDER?

# 1.

The original formula for 7 Up was created in 1929 by Charles Leiper Grigg. It was initially marketed as a patent medicine, like many soft drinks during the Great Depression.



# 2.

The 'lemon-lime soda' contained lithium citrate, and although Grigg never confirmed the origin of the name '7 Up', one theory is that the number 7 refers to the atomic mass of lithium.



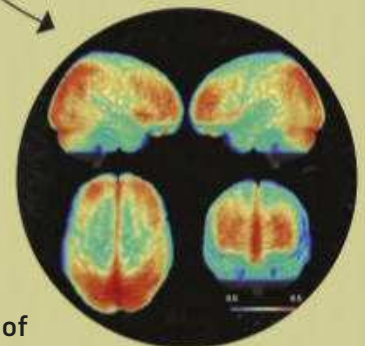
# 3.

Lithium citrate was known to be a mood-stabilising drug (lithium tablets are shown on the left), and the drink was sold as a pick-me-up and hangover cure. An early version of Coca-Cola also contained lithium citrate.



# 4.

The drug was removed from 7 Up in 1948, but lithium compounds are still used today to treat bipolar disorder (image of bipolar brain can be seen on the right). They strengthen connections in the brain regions that regulate mood and behaviour.







## Why do we hate the sound of our own voices?

ALEXANDER BOSWELL, BUDLEIGH SALTERTON

Most of us are happy with our voice until we hear it recorded. One reason is that our recorded voice sounds higher pitched than we're used to. This is because we usually hear our voice, in part, as it's conducted through the bones in our head, which makes it sound deeper. Another reason is that when we hear a recording of our voice, we scrutinise ourselves as we would others, and we're surprised and discomfited by just how much (we think) we're giving away in terms of our personality. **CJ**



## How free-range are free-range chickens?

EMMA SPRATLEY, NEWCASTLE-UNDER-LYME

UK regulations require free-range poultry to have access to the outside during daylight hours via 'popholes'. Each bird needs to have at least 4m<sup>2</sup> of outside space. The indoor barn where the birds perch and lay eggs can have up to nine birds per square metre. EU organic standards require lower densities of six birds per square metre in the barns, and maximum flock numbers of 3,000 birds. Under certain organic standards, beak trimming is not permitted, but this is allowed with free-range hens. **LV**

## THE THOUGHT EXPERIMENT

# WHAT WOULD HAPPEN IF... THE OCEAN FROZE OVER?



### 1. OIL PRICES SKYROCKET

Half the world's oil is transported by sea. With the shipping lanes frozen over, the international oil market would see drastically restricted supply, just when oil is needed more than ever for heating. This would trigger global economic collapse, leading to martial law in many countries.



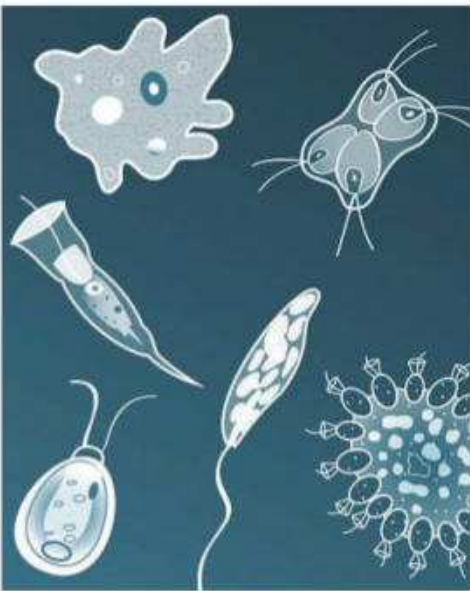
### 2. FOOD CHAIN COLLAPSE

The layer of ice over the oceans would block out most of the light in the surface water. This would kill off marine algae, and the effects would ripple up the food chain until the oceans were almost sterile. Only deep-sea organisms living around hydrothermal vents would survive.



### 3. PLANTS DIE

Ice reflects more sunlight than water, so the global climate would cool drastically, freezing the land as well. Plants would die from lack of water, resulting in less CO<sub>2</sub> absorption, so CO<sub>2</sub> from volcanoes would slowly build up in the atmosphere and warm the planet back up – but it could take millions of years to thaw the ice.



### 4. IT'S HAPPENED BEFORE

Geological evidence suggests the oceans may have frozen at least twice before. The last time was around 650 million years ago. Enough single-celled organisms survived that event to repopulate the Earth, but the fossil record isn't good enough to tell if there were other, multicellular life forms that weren't so lucky.















# Is the sugar in fruit bad for us?

ROGER BRITTON, VIA EMAIL

The sugar in fruit is mostly fructose and glucose. Glucose is the primary food molecule, and can be used directly by the cells in your body. Fructose, however, must be converted into glucose before it can be used. This happens in the liver, but there is a limit as to how fast the liver can process fructose. When it is overloaded, it will instead convert the fructose into fat – so high-fructose diets tend to make you obese.

But surprisingly, a diet that’s rich in fresh fruit isn’t a high-fructose diet! That’s because fruits have a lot of fibre and water that slow down your digestion and make you feel full. In fact, research has found that apples and oranges are some of the most filling foods per calorie – higher than steak or eggs. So although a medium apple contains 19g of sugar, including 11g of fructose, you will feel less hungry afterwards than if you had the same amount of sugar from a fizzy drink (roughly half a can of Coke).

It is almost impossible to get too much sugar from fresh fruit, but this doesn’t apply to fruit juice or dried fruit. They are much easier to binge on. **LV**

	<b>GRAPES</b> (1 serving, 151g)	<b>23g</b>
	<b>1 MEDIUM APPLE</b> (182g)	<b>19g</b>
	<b>1 MEDIUM PEAR</b> (178g)	<b>17g</b>
	<b>PINEAPPLE</b> (1 serving, 165g)	<b>16g</b>
	<b>1 MEDIUM BANANA</b> (118g)	<b>14g</b>
	<b>1 MEDIUM PEACH</b> (150g)	<b>13g</b>
	<b>1 MEDIUM ORANGE</b> (131g)	<b>12g</b>
	<b>HALF A WHITE GRAPEFRUIT</b> (118g)	<b>9g</b>
	<b>WATERMELON</b> (1 serving, 152g)	<b>9g</b>
	<b>STRAWBERRIES</b> (1 serving, 152g)	<b>7g</b>
	<b>RASPBERRIES</b> (1 serving, 123g)	<b>5g</b>
	<b>1 MEDIUM TOMATO</b> (123g)	<b>3g</b>



## Why do wasp and bee stings hurt so much?

SOPHIE ELLIOTT, ABERDEEN

Wasp and bee venom are quite different chemically, but they both contain peptides (amino acid chains) that have evolved specifically to cause pain in other animals. The social bees and wasps use this to defend their nests; the solitary ones, just to discourage predators from eating them. Honeybee venom contains a peptide called melittin that directly activates the pain receptors in your skin. **LV**

GETTY X2, NASA ILLUSTRATION: PETER SUCHESKI





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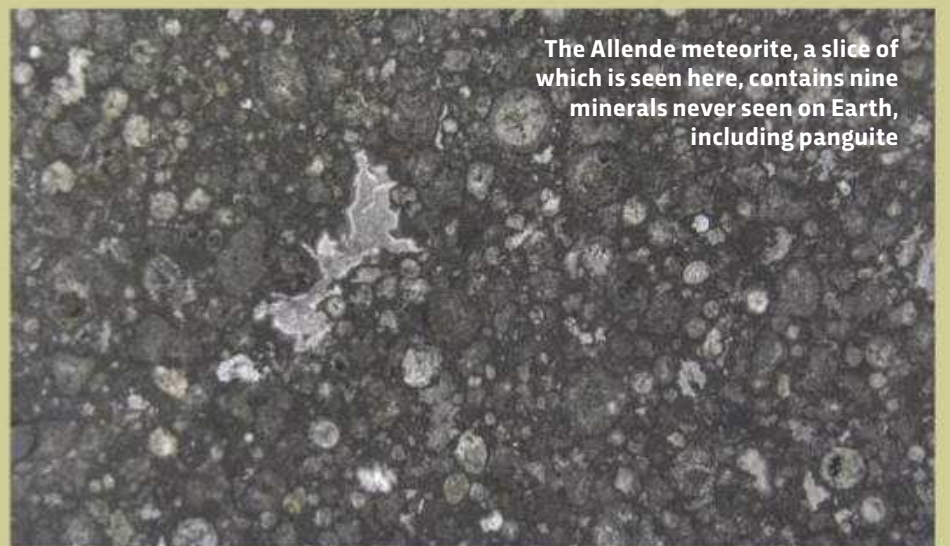


# Why do we smile?

CERES WOOLLEY MAISCH, LONDON



Smiling is a social signal which, usually, communicates to others our positive emotion and intent. When we feel good or we're pleased to see someone, this emotion plays out in our facial expression. This sounds very jolly, but in some contexts smiles can also convey fear or submissiveness. Researchers who studied the facial expressions of martial arts fighters facing off before a clash found that those who smiled were more likely to go on to lose: the theory is that in this case their smile betrayed their fear or inferiority. A related important distinction is between genuine, involuntary smiles, which are marked by greater creasing around the eyes, and deliberate or feigned smiles, which are deployed strategically to convey happiness, pleasure or deference, and lack the telltale eye wrinkling. **q**



The Allende meteorite, a slice of which is seen here, contains nine minerals never seen on Earth, including panguite

## Could there be materials on other planets that we don't have on Earth?

JAMES WHALLEY, COLCHESTER

Yes, without a doubt – because every so often, we get a delivery of such stuff from meteorites. Chemical analysis has so far identified around 300 minerals in these chunks of debris from deep space, including around 40 that have only ever been seen in meteorites.

One of the most intriguing materials so far was found in the Allende meteorite, which exploded over Mexico in 1969. After analysing samples from the debris, scientists in 2012 announced the discovery of a material that has not only never been seen on Earth, but wasn't even known to be possible. Named 'panguite' – after the giant Pan Gu who created the Earth in Chinese mythology – it consists of a bizarre mix of elements, including titanium, zirconium and scandium. **RM**



## WHO REALLY DISCOVERED?

## THE HEAT FROM THE BIG BANG?

ROBERT  
WILSONARNO  
PENZIASANDREW  
MCKELLAR

In 1964, physicists Arno Penzias and Robert Wilson at the Bell Telephone Laboratories in New Jersey were investigating interference that was affecting a horn-shaped antenna built for satellite communications. Their analysis suggested it was emanating from an incredibly feeble source of heat, amounting to just a few degrees above absolute zero ( $-273^{\circ}\text{C}$ ) – and bizarrely, it seemed to be coming from everywhere in the sky at once.

When the pair described their findings to astrophysicists at nearby Princeton University, the truth emerged: Penzias and Wilson had detected the heat left over from the Big Bang. The momentous discovery garnered the pair a share of the Nobel Prize for physics in 1978.

But by then, it was clear they *weren't* the first to detect this primordial heat. In 1940, Canadian astronomer Andrew McKellar found molecules in space whose properties revealed the temperature of their surroundings. He showed that these suggested the whole of space was a few degrees warmer than absolute zero, but the significance of this was missed because theorists had yet to work out the consequences of the Big Bang in detail. Sadly, McKellar never lived to see his claim vindicated: he died in 1960, aged just 50. **RM**



The heat left over from the Big Bang is known as the cosmic microwave background



## What would happen if a person just ate meat and nothing else?

REBECCA SEDGWICK, DORKING

Not much – at least in the short term. In a 1928 study, two ‘normal’ men ate only meat for one year, under the supervision of medical researchers in New York. At the end of the year the men showed “no specific physical changes in any system of the body”.

Today, fans of a ‘carnivore diet’ claim it brings weight loss and improves digestive health. But with so much evidence of plant foods’ anti-cancer effects, the jury is out on whether a meat-only diet is actually healthy in the long term. **ED**

## IN NUMBERS

# 12g

The amount of salt you'd have to eat a day before experiencing any adverse impact on health, according to new research at McMaster University, Canada. Only in China does the average daily diet exceed this level.

# 14 days

The amount of time it takes an African killifish, from birth, to reach sexual maturity – a record among vertebrates.

## Has there ever been a Small Hadron Collider?

PAM GOUDIE, ISLE OF LEWIS



The famous Large Hadron Collider (LHC) has made headlines with its unprecedented power to probe the nature of matter. But the LHC is the culmination of decades of research into ways of smashing together subatomic particles with ever greater violence.

In the 1960s, physicists began investigating ways of boosting the energy of particle collisions by running two beams of particles into each other, rather than simply smashing one beam into a stationary target. In 1970, scientists at CERN near Geneva unveiled the Intersecting Storage Rings (ISR), which used magnets to accelerate and then bring together two streams of protons (particles belonging to the family known as ‘hadrons’). It was the world’s first hadron collider.

Despite being just 150m across, the design of the ISR boosted the impact energy 30-fold compared to hitting a fixed target. Over 30 years later, the same basic idea was incorporated into the LHC, which is over 8.5km across and achieves energies 200 times greater still. **RM**





## WHAT IS THIS?

### Eye in the sky

Around the size of a grapefruit, this very cute-looking drone is called the JEM Internal Ball Camera, or Int-ball for short. Int-ball lives on the Japanese Kibo module of the International Space Station, and propels itself around using internal fans – either autonomously or under remote control. Its 'eye' is actually a single camera between the two blue rings (which are just for show), and its job is to take pictures of various activities and equipment and relay them to Ground Control – saving the Japanese astronauts a job that previously took up around 10 per cent of their time.



# COULD HUMANS LIVE IN UNDERWATER CITIES?

We teamed up with the folks behind BBC World Service's *CrowdScience* to answer your questions on one topic. You can tune into *CrowdScience* every Friday evening on BBC World Service, or catch up online at [www.bbcworldservice.com/crowdscience](http://www.bbcworldservice.com/crowdscience)

## Why would we need underwater cities?

As sea levels and populations rise, and we begin to run out of space on land, some pioneers think that we should begin to colonise the oceans. French architect Jacques Rougerie, now aged 73, has designed dozens of underwater habitats over his career. In a boatyard in Bordeaux lies the first component of his latest idea: SeaOrbiter, a floating research colony that extends 31m beneath the surface. Meanwhile, Canadian inventor Phil Nuytten imagines a settlement much deeper underwater, which would harvest resources from thermal vents. We're not talking city-sized habitats yet, but every journey starts with a single step...

## Has anyone already tried living underwater?

Diving pioneer Jacques-Yves Cousteau built the first inhabited underwater habitat in 1962. Called Conshelf 1, this steel cylinder was home, for a week, to two divers. They were submerged off the coast of Marseilles at a depth of 10m, studying marine life and even building an underwater farm.

Underwater living isn't just for oceanographers, though. In 1970, an all-female team of US 'aquanauts' spent over 10 days 15m underwater in the Caribbean. The aim of the mission, called Tektite II and part-funded by NASA, was to study the psychological effects of living in close quarters, in an environment similar to that of a spacecraft. Nowadays, there are a handful of underwater research labs around the world.



## What are the main obstacles to living underwater?

Breathing is an obvious issue. Oxygen will have to be supplied from the surface, and underwater citizens will also need access to fresh water, food and power. One of the most ambitious habitats to be proposed so far is Japanese architectural firm Shimizu Corporation's 'Ocean Spiral'. This deep-sea city would use the temperature difference of deep and shallower waters to drive a power generator, while drinking water would come from desalination technology, and food from underwater farms. The aim is to house 5,000 people by 2030. The cost? A mere \$26bn. Our oceans may be closer than outer space, but they're just as expensive to explore.

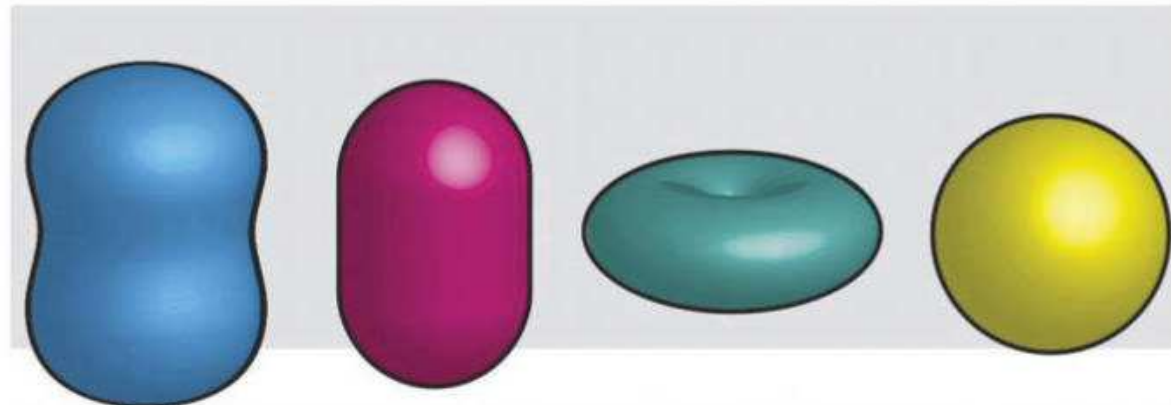


Marnie Chesterton is the presenter of *Underwater Cities*, an episode of *CrowdScience*. It can be streamed at [bit.ly/crowd\\_science\\_underwater](http://bit.ly/crowd_science_underwater)



# What shape are subatomic particles?

MARK BUCKMASTER, LEICESTER



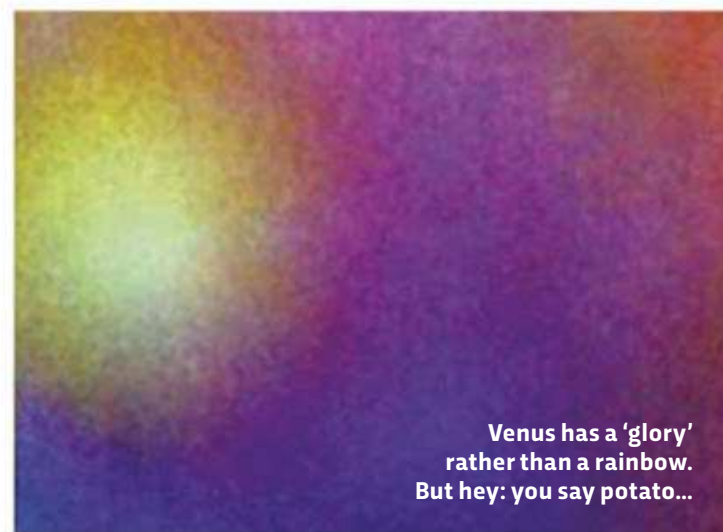
**Peanut**  
Produced by the fastest quarks, spinning in the same direction as the proton

**Rugby ball**  
Produced by quarks that are moving slower than in the peanut and bagel shapes

**Bagel**  
Produced by the fastest quarks, spinning in the opposite direction from the proton

**Sphere**  
Produced by the slowest quarks

We usually think of electrons, protons and the like as being perfectly spherical, like tiny marbles. Yet while this seems to be pretty accurate in the case of electrons, studies of protons have revealed that they are constantly changing shape. By firing particles at them and analysing the resulting trajectories, physicists have found that the shape of protons is affected by the speed of even smaller particles within them called quarks, three of which are jostling around inside each one. **RM**



Venus has a 'glory' rather than a rainbow. But hey: you say potato...

## Is it true that Venus has its own form of rainbow?

DAMION RIES, RENO, USA

Venus has an optical phenomenon called a 'glory' which – like a rainbow – forms when sunlight falls on cloud droplets. However, glories are caused by the interference of light waves within droplets, whereas rainbows are caused by the reflection, refraction and dispersion of light. Unlike the broad arc of a rainbow, a glory is typically seen as a series of coloured concentric rings. In 2011, a Venusian glory was observed by ESA's Venus Express probe, probably caused by sunlight interacting with the sulphuric acid/ferric chloride droplets in the planet's atmosphere. **AGu**

## QUESTION OF THE MONTH

### Do guide dogs know that their master is blind?

PAD SCANLON, LONDON

Although all dogs show signs of having 'theory of mind', which enables them to grasp the fact that we think differently from them, it's unlikely that they are capable of extending this to knowing the reason why one person behaves differently to another. The concept of vision, and therefore the loss of it, is a complex one, so we don't think dogs have an understanding of what it means to be blind. But, of course, they can learn what things a blind person needs help with, and adjust their behaviour accordingly. Interestingly, studies show that guide dogs will still look to their master's face for cues when begging for food, just as a sighted person's dog would. **cc**

## WINNER!

Pad wins a Google Home Mini.

The most affordable and compact of Google's Assistant-enabled speakers, the Home Mini (£49, [bit.ly/home\\_mini](https://bit.ly/home_mini)) can be used on its own or alongside other Google Home devices, and will let you control smart home devices, play music, search for information and more – all by the power of voice alone.



## NEXT ISSUE:

What's the point in laughter?

Is MSG bad for you?

Why are bald heads so shiny?

Email your questions to [questions@sciencefocus.com](mailto:questions@sciencefocus.com) or submit online at [sciencefocus.com/qanda](https://sciencefocus.com/qanda)



# OUT THERE

WHAT WE CAN'T WAIT TO DO THIS MONTH

OCTOBER 2018

EDITED BY HELEN GLENNY





01

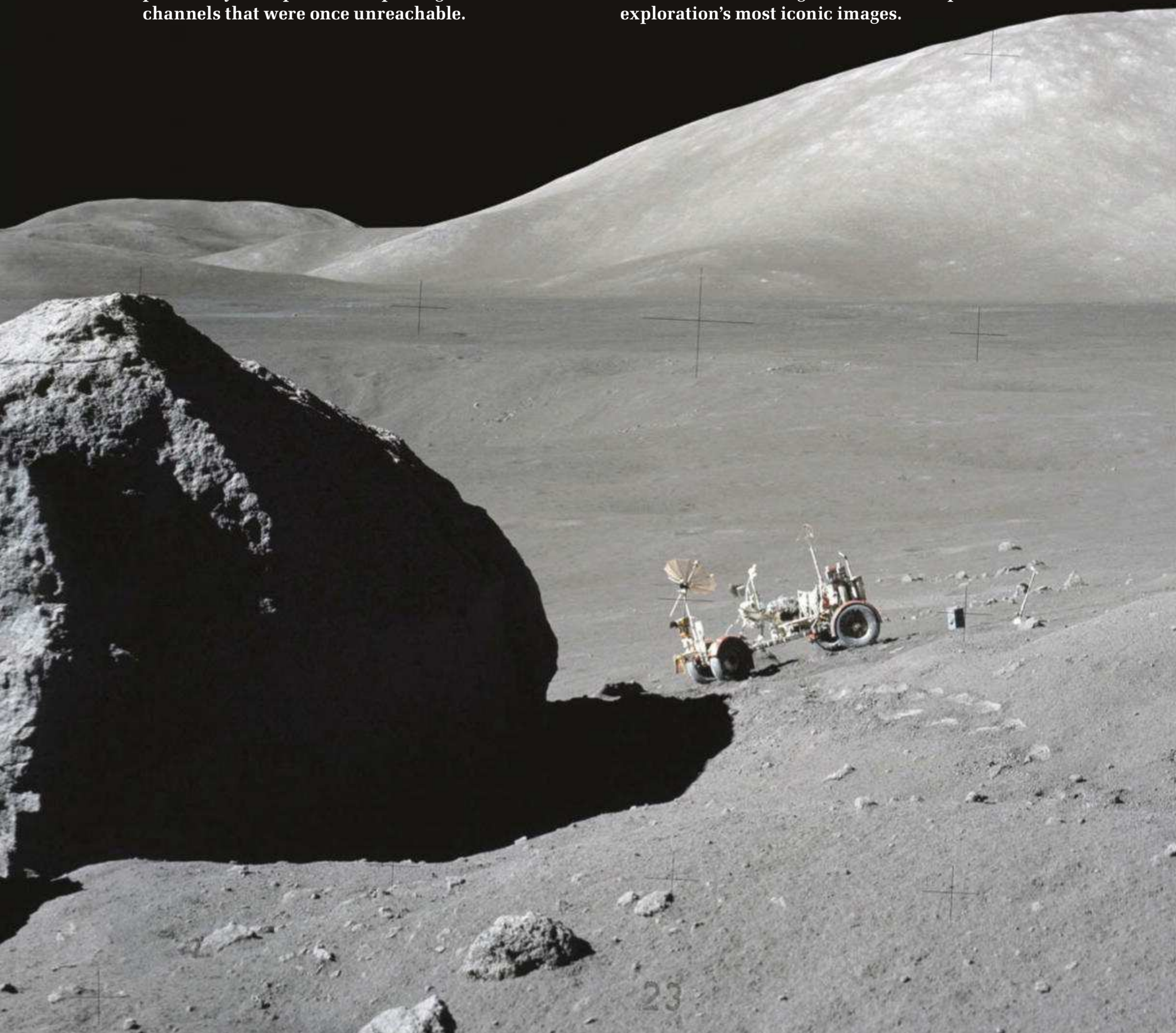
**THE HISTORY OF  
SPACE EXPLORATION**  
**ROGER D LAUNIOUS**OUT 11 OCTOBER  
(£24.95, THAMES & HUDSON)

# EXPLORE SPACE

Geologist and astronaut Harrison Schmitt, seen here at the Taurus-Littrow landing site, travelled to the Moon as part of the Apollo 17 mission. It was the last manned mission to the Moon to date.

The crew returned with 110kg of rock and soil samples, more than was returned from any other lunar landing site. Apollo 17, like Apollo 15 and 16, used a Lunar Roving Vehicle, enabling astronauts to travel farther on the Moon's surface than had previously been possible, exploring mountains and channels that were once unreachable.

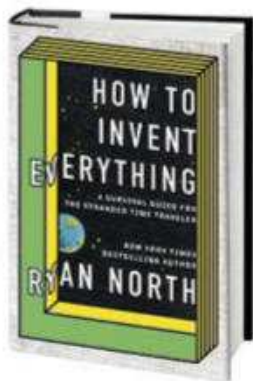
This shot and many other pictures of NASA's most significant moments have been compiled into *The History Of Space Exploration*, an in-depth account written by former NASA chief historian, Roger D Launious. The book traces a path from the first gunpowder rockets through to the Apollo missions, the launch of the Hubble Space Telescope and on to the future of space travel. Launious has delved deep into NASA archives and other international collections for this book, illustrating it with some of space exploration's most iconic images.





## 02

**HOW TO  
INVENT  
EVERYTHING**  
**RYAN NORTH**  
OUT 20 SEPTEMBER  
(£16.99, VIRGIN BOOKS)



# INVENT EVERYTHING

In his latest book *How To Invent Everything*, Canadian computer scientist and comic writer RYAN NORTH takes a look at the 200,000 years of inventions and discoveries that have helped to shape our society and humanity itself. He talks to HELEN GLENNY

## Your book appears to be a repair guide for a time machine?

Yes. But, as the time traveller finds out, time machines are really complicated, with no user-serviceable parts. If you're stuck in the past and your time machine's broken, you're not going to fix it. Instead, we'll help you bring the future back by explaining how to reinvent civilisation from scratch.

## Let's say we travelled back to between 200,000 BC and 50,000 BC. Why's that such a key time period?

Around 200,000 BC is when we start to see anatomically modern humans, whose bodies look like ours. Then around 50,000 BC we get behaviourally modern humans, who start behaving like us: they've started doing things like burying their dead, creating art and wearing jewellery.

We're not really sure what changed around 50,000 BC, but one theory is that we finally invented language. Language is hard to invent – we've only done it a couple of times throughout history. But it's so powerful: it's what allows ideas to survive outside the host, and it lets you send information that can last longer than the human body lasts. So if you're in that time period, teach the humans language. You could be the most influential person in history.

## You say spoken language is one of five fundamental technologies upon which civilisation was founded. What are the other four?

Written language is the next, then numbers, the scientific method, and finally the calorie surplus – producing more food than you eat.

## I'm a big fan of calorie surplus. Why's that so important?

It allows you to specialise. If you have someone else taking care of food production, you're not worrying where your next meal comes from, which frees you up to worry about other stuff – like why do apples fall from trees, or why do the stars move in the sky? Having reliable food unlocks the kind of questions that lead to an industrial society.

## What significant advances can we make quickly?

You know the canary in the coal mine? Birds have high metabolisms and breathe faster than humans, so if there's not enough oxygen in the mine the bird will faint first and the miners can escape. We only discovered that in the 20th Century. We'd already invented radios by then, and we'd been mining for thousands of years!

It makes you wonder: what else are we just not seeing, even though we have all the parts in front of us? This happens a lot. The Ancient Greeks noticed some rocks were natural magnets, and stuck together. They thought, "That's weird, we'll use that for fortune telling". Thousands of years later, Chinese civilisation invented the compass, and that unlocks navigating the entire world. The earliest compasses were just magnetic rocks tied to strings. The string lets the rock rotate freely, and the rock points to magnetic north.

So tying a rock to a string took us over 1,000 years, which is just embarrassing. We can have all the parts we need and we still won't think to put them together for thousands of years, and that's



a story that's repeated throughout the course of history.

## Which technology would be the hardest to invent?

Music is interesting. You can easily teach someone how to make instruments, and even read music, but what does middle C sound like? All of music hinges on being able to produce a certain frequency at any point in history. It all comes down to getting a piece of card and putting it into a wheel with spokes and turning the wheel fast enough to produce a known frequency. All of music relying on a card in wheel – I thought that was crazy.

## What inspired you to write the book?

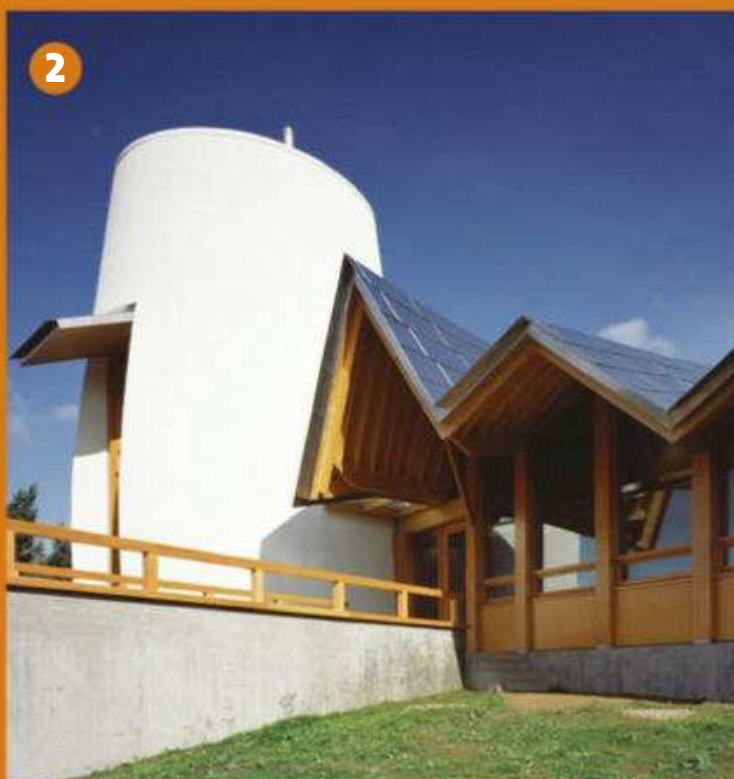
I was afraid, as a kid, of arriving in the past and saying, "Guys, I'm from the future, it's great! We have computers!" and they'd say "How do they work?" and I'd say "I don't know, but when you figure it out it's going to be awesome!" If I was sent back in time now I'd be a really useful time traveller.

### DISCOVER MORE



Listen to our full interview with Ryan North on the *Science Focus* podcast. Visit [sciencefocus.com/sciencefocuspodcast](https://sciencefocus.com/sciencefocuspodcast)





03

**LIVING WITH BUILDINGS**WELLCOME COLLECTION  
4 OCTOBER 2018 –  
3 MARCH 2019**BUILD HEALTH**

Our homes, workplaces and the buildings we visit can influence our health in powerful ways. These three buildings have all helped to boost our wellbeing, and they're all being featured in the Wellcome Collection's new exhibition, *Living With Buildings*.

**1. FINSBURY HEALTH CENTRE, LONDON**

Presented with a humanitarian brief for a healthcare centre to support a deprived community, architect Berthold Lubetkin designed this free access, patient-centred building, which opened in 1938 – a decade before the establishment of the NHS. Lubetkin created a welcome ambience using a curved façade, light-filled lobby and easy-to-navigate layout.

**2. MAGGIE'S CENTRE, DUNDEE**

Terminally ill cancer patient Maggie Keswick Jencks believed that cancer care could be improved through good design. Maggie's Centres were developed as a contrast to the harsh, institutional design of hospitals, and they're situated near, but never in, existing hospitals. Like this one in Dundee, designed by Frank Gehry and opened in 1996, they create a friendlier space for cancer patients to spend time.

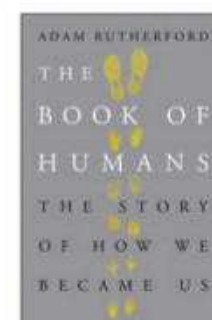
**3. PAIMIO SANATORIUM, FINLAND**

Developed in 1929 as a tuberculosis sanatorium, this building was designed by Alvar Aalto to make its own contributions to the healing process.

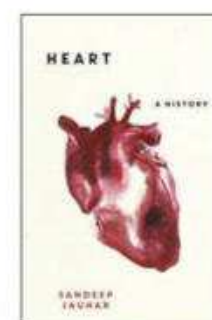
He designed silent basins and strategic lighting so that patients wouldn't disturb each other, and the building included large balconies and a roof deck, as the only known cure at the time was rest, clean air and sunshine.

**READ ON**

*Have a gander at this month's best science books*

**EXCEPTIONAL BEINGS****ADAM RUTHERFORD**OUT NOW (£18.99,  
WEIDENFELD & NICOLSON)

*Turns out we're not the only species that makes tools or uses fire – so what does that mean for humanity? Adam Rutherford takes us on a myth-busting tour of human history, exploring whether we really are as exceptional as we think.*

**HEART: A HISTORY****SANDEEP JAUHAR**OUT 27 SEPTEMBER  
(£14.99, ONEWORLD)

*Cardiologist Sandeep Jauhar tells the story of the human heart, weaving in gripping scenes from operating theatres, his family's history of heart problems, and the issues our most important organ might face in the future.*

**THE SKY AT NIGHT BOOK OF THE MOON****DR MAGGIE ADERIN-POCOCK**OUT NOW  
(£9.99, BBC BOOKS)

*The Moon influences Earth's tides, dictates the length of the day and potentially played a role in the creation of life on Earth. Dr Maggie Aderin-Pocock explores how well we know our closest neighbour.*

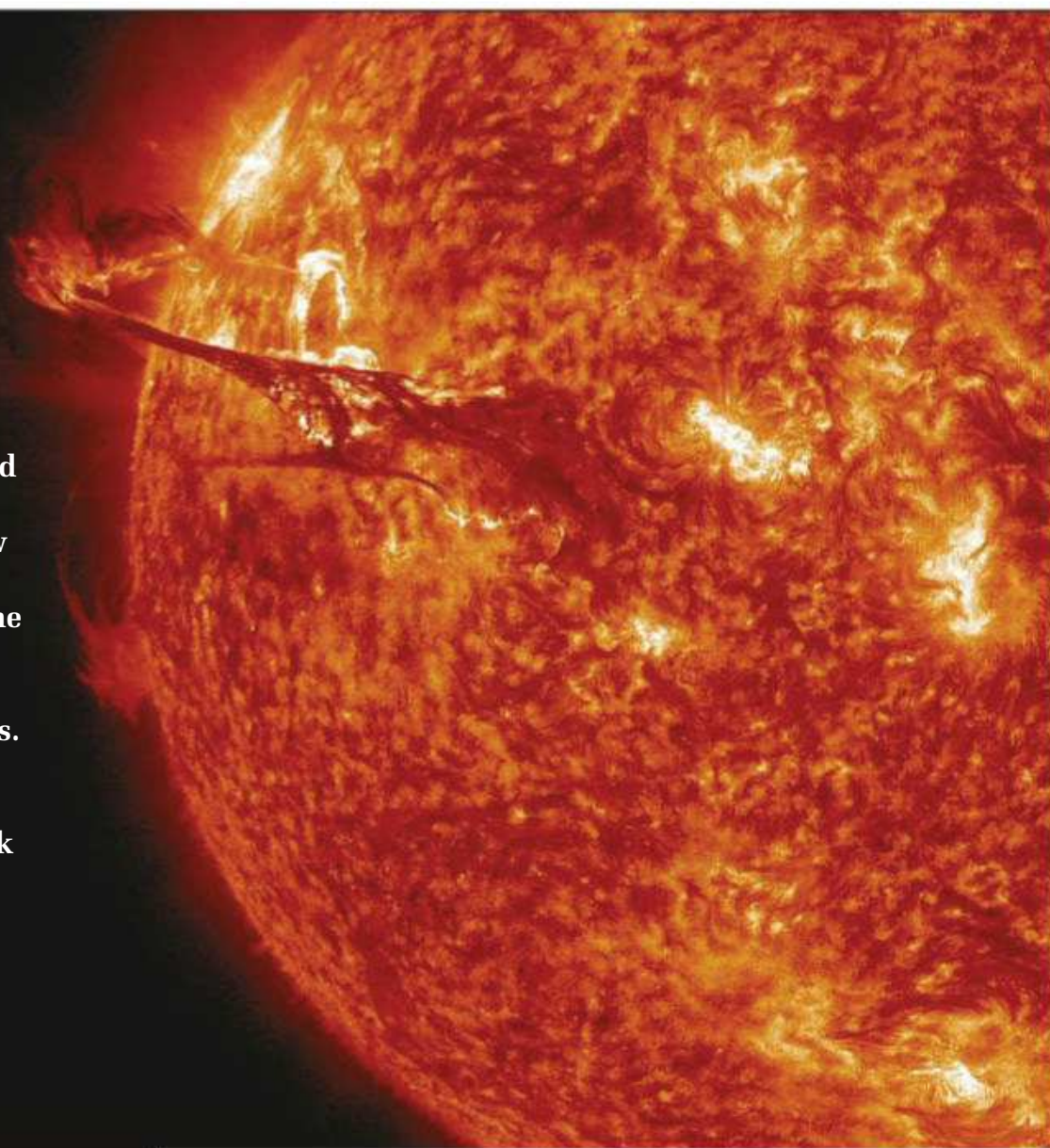


04

**THE SUN: LIVING  
WITH OUR STAR**SCIENCE MUSEUM, LONDON  
6 OCTOBER 2018 – 6 MAY 2019**SUNBATHE**

As we head into autumn, the Science Museum in London is letting us sit in a deckchair, nestle our feet into the sand and feel the warmth of sunlight on our skin once more. This is just one of the interactive experiences at their new exhibition *The Sun*, which also includes a display that allows visitors to see the Sun rise in different seasons. The exhibition showcases the beauty, bounty and terrifying power of our star, examining ancient beliefs and rituals and introducing upcoming NASA and ESA solar missions.

The Sun frequently sends charged particles and magnetic fields hurtling through space in powerful solar storms, and if one of these was to hit Earth, it could knock out electricity grids, satellite navigation and communication for weeks. But you can help protect the world from devastating solar storms, with a citizen science project that's being launched by the Science Museum and Reading University. All you have to do is assess images from the twin NASA STEREO spacecraft – no expert knowledge needed.



1. An early 1960s Ferranti silicon solar cell.
2. A tablet sundial dating from 1556.
3. A brass astronomical spectroscope, used in the late 19th Century by Sir Norman Lockyer to study solar prominences.
4. The Kew photoheliograph – the world's first solar camera. It was built in 1854 for the Kew Observatory.

**TAKE PART**

Join the effort to protect our planet from solar storms! Visit [bit.ly/solar\\_storm\\_research](http://bit.ly/solar_storm_research)

**SAVE THE WORLD THROUGH  
CITIZEN SCIENCE**

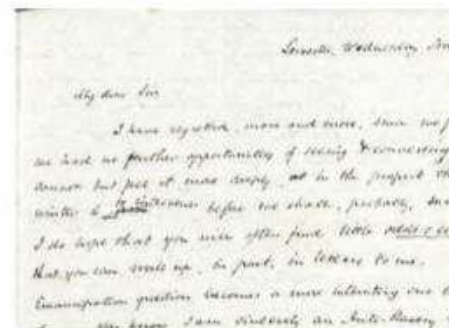
Here are three other projects that you can sink your teeth into. Get involved at [zooniverse.org](http://zooniverse.org)

**BAT DETECTIVE**

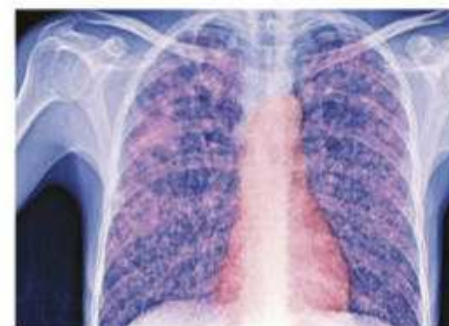
Help scientists identify the recorded calls of 40+ European bat species, so they can develop a new program that extracts information from their calls.

**ANTI-SLAVERY  
MANUSCRIPTS**

The Boston Public Library team needs your help transcribing handwritten correspondence exchanged by anti-slavery activists in the 19th Century.

**BASH THE BUG**

Antibiotic resistance is rising, but with new sequencing techniques and your help, researchers can work out which changes in the genome lead to resistance.







# 05 LEARN FROM EXTREME EXPERTS

Not all science takes place in a lab! Here are three talks that examine the link between exploration and scientific discovery

## **SUMMITTING THE SCIENCE OF EVEREST**

OXFORD PLAYHOUSE, 5 OCTOBER, £7

[bit.ly/ever35t](http://bit.ly/ever35t)

Plasma physicist Melanie Windridge has recently arrived home from climbing Mount Everest. She'll be discussing new developments in weather prediction, introducing the technology that keeps climbers connected on the roof of the world, and explaining how she went about training for such an extreme feat of endurance.

## **THRIVING AT THE LIMITS: RISKS AND REWARDS AT THE EDGES OF LIFE**

PACCAR THEATRE, DUBLIN, 26 SEPTEMBER, FREE

[bit.ly/thrivdub](http://bit.ly/thrivdub)

Activities such as space missions, deep-sea diving and long-distance sailing demand immense physical and psychological efforts. There's fear, but also pain, sleep deprivation, hunger and monotony. Psychologist Emma Barrett explores whether we all have the ability to thrive at the extremes.

## **EXPLORING THE UNKNOWN**

GUILDHALL ARTS CENTRE, GRANTHAM, 26 SEPTEMBER, £7

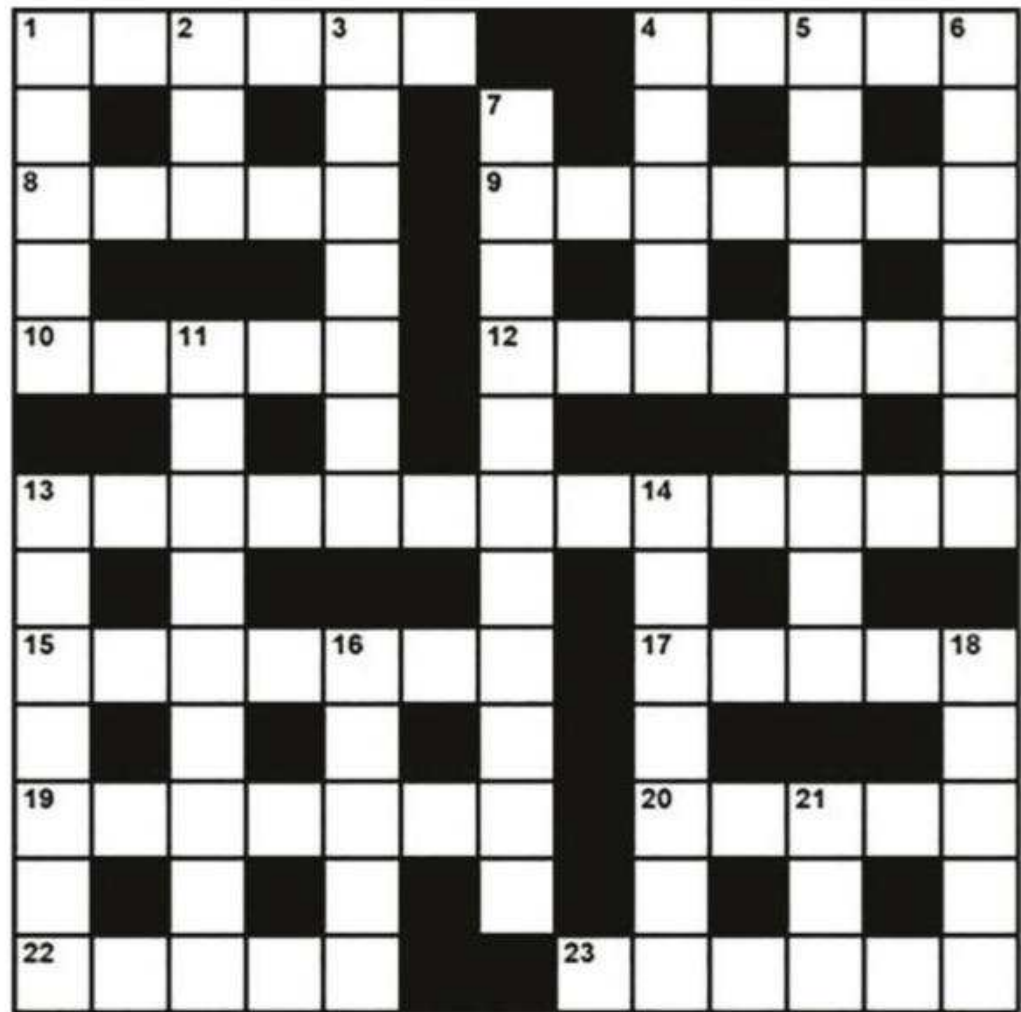
[bit.ly/roysoc18](http://bit.ly/roysoc18)

Early scientific research was often fuelled by intrepid explorers travelling long distances to unknown places. At this event, a Royal Society expert panel will be discussing the importance of exploration in scientific endeavour today, and explaining how fieldwork still plays a vital part in new scientific developments.



# BBC FOCUS CROSSWORD

GIVE YOUR BRAIN A WORKOUT



## ACROSS

- 1 Strange being, new but not malignant (6)
- 4 Maxim initially said about gold producer (5)
- 8 Coordinates left space for plant tissue (5)
- 9 Somehow trains a workman (7)
- 10 Navigation aid that looks both ways (5)
- 12 Head of broadcasting argues with queen in program (7)
- 13 Friend finds age only too wrong for study (13)
- 15 Marine creature has silly problem with keys (3,4)
- 17 Time to adjust aim with large tongue (5)
- 19 Wicked to have registered law-breaking, but it has a point (7)
- 20 Stone object is a bird (5)
- 22 Delight about bishop getting some land of his own (5)
- 23 Certain amount of qualification (6)

## DOWN

- 1 Pugilist sees underwear not containing rear (5)
- 2 See nothing in senility (3)
- 3 Troublesome location for a eucalyptus, say (3,4)
- 4 More about taking temperature underground (5)
- 5 Note must sort out desert weather (4,5)
- 6 Interaction as sulphur, yttrium and nitrogen turn grey (7)
- 7 Environmental process to produce lightweight bike (6,5)
- 11 Mouth greeting generated while asleep (5,4)
- 13 Quietly go bats, organising correspondence (7)
- 14 Cut pole into pieces – into eight pieces (7)
- 16 Picture one game differently (5)
- 18 Illuminated concerning quantity (5)
- 21 Same level within department (3)

GETTY X4

## ANSWERS

For the answers, visit [bit.ly/BBCFocusCW](http://bit.ly/BBCFocusCW)  
Please be aware the website address is case-sensitive.

NEXT MONTH IN

FOCUS

# Recreating Neanderthals

MEET THE SCIENTISTS WHO ARE BUILDING NEANDERTHAL BRAINS



## PLUS

Talking with wolves



The British Gut Project



Election hacking







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**ASTRO FI**  
TELESCOPE



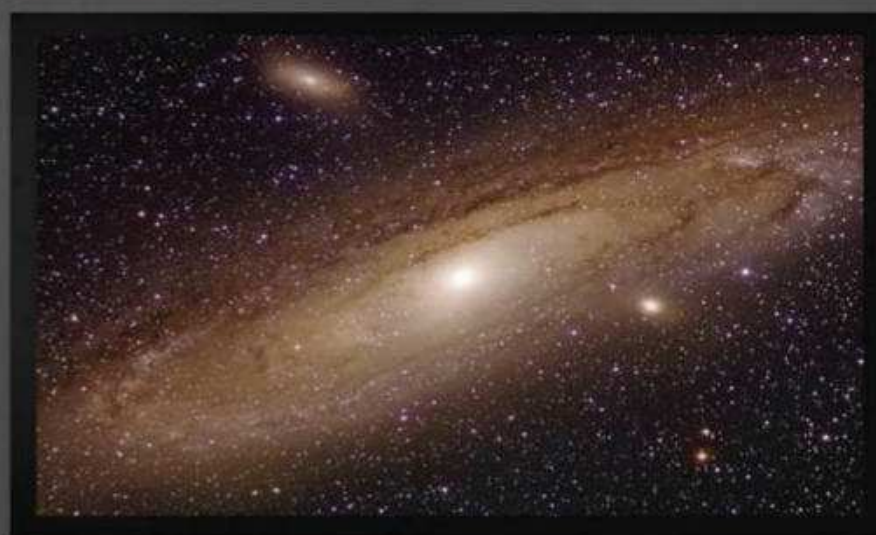
**GALAXY**  
ON GLASS

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in any room*

Spectacular wall art from  
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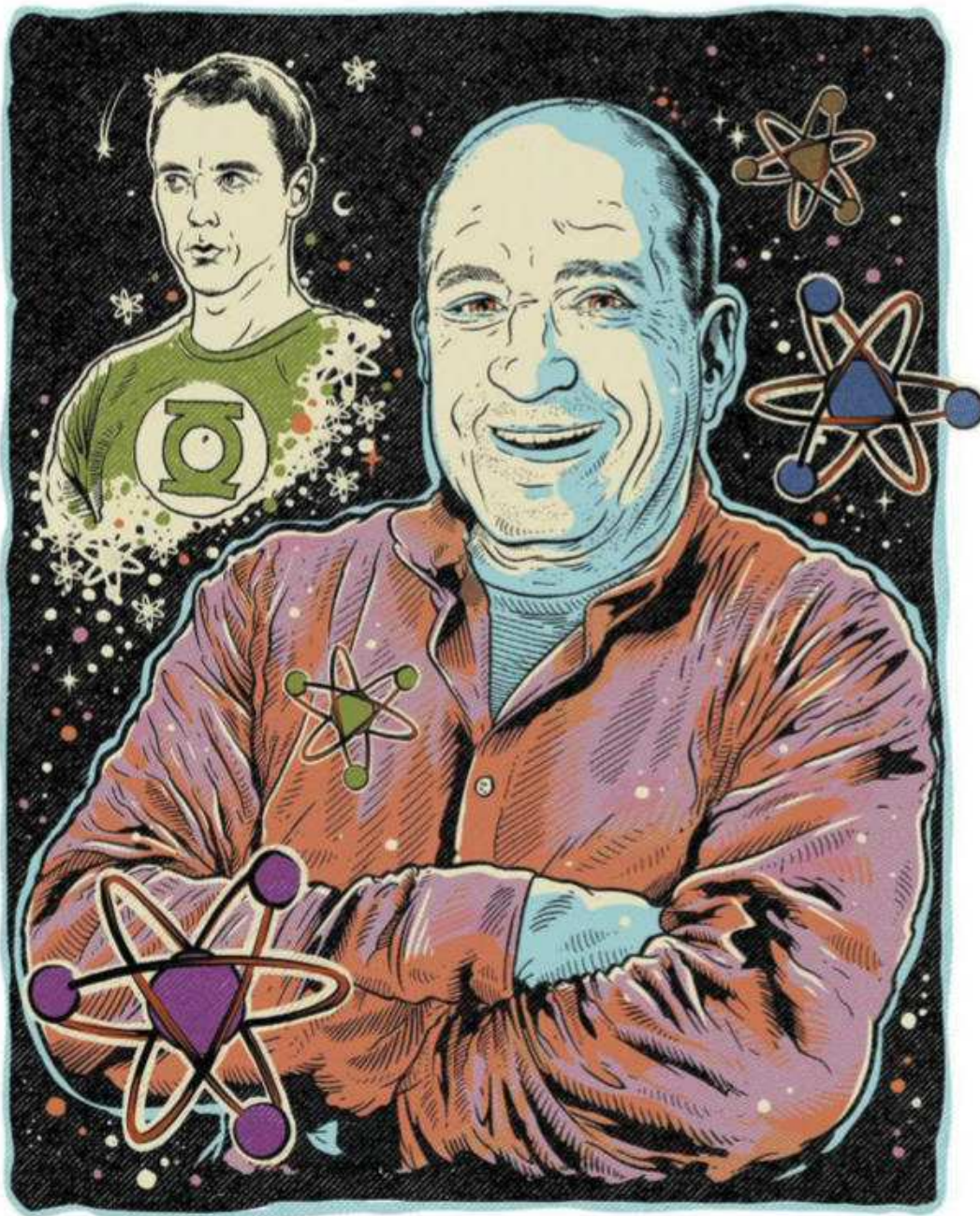
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MY LIFE SCIENTIFIC

# David Saltzberg

Attention *The Big Bang Theory* fans! **Helen Pilcher** talks to the hit TV comedy's science consultant, particle physicist **David Saltzberg** from UCLA

The *Big Bang* team visited David's students at home, but decided their digs were "too dark and gloomy" to be the model for Sheldon's apartment.

## How did you get involved in *The Big Bang Theory*?

Back in 2006, a friend of a friend of a friend who was a producer was putting the pilot together, and wanted advice from a local scientist. I read the script and corrected a piece of physics about Special Relativity. Then, when the show was commissioned, I became their science consultant. I had no idea that would last for 12 years.

## Do you watch the show being filmed?

Yes, but it's very rare they need me. Once Leonard dropped a bottle

down an elevator shaft and the sound effects guy needed to know how long to wait before you hear the crash. I did that in my head while a live audience was waiting for the answer.

## Do you get to add any jokes?

Not often. Once, Sheldon needed to tell a bad physics joke and I wrote it. When they recorded it the audience laughed, but then they edited out the laughter because it wasn't meant to be funny!

## Have you been in the show?

I was an extra in a cafeteria scene

once, when Howard first starts dating Bernadette. I was only on-screen for a second, but my inbox the next day was filled with people who saw me.

## Are any of the characters based on real life people?

Only very loosely. A long time ago, one of the co-creators worked with some people in the computer science world. That was the jumping-off point. Since then, the characters have all developed and now, after 250 episodes, it's as if they've all become real people.

## Do you work on spin-off series *Young Sheldon*?

Yes. In that, Sheldon is a kid... so instead of doing high-level discussions of particle physics or string theory, I get to do ninth grade chemistry homework!


## What's your biggest worry?

I constantly live in fear of making a mistake on the show. If I do, there's a whole internet out there that will pile on. Part of my job is to be someone that the writers can forward hate mail on to!

## What's been the highlight of your career so far?

I've always tried to work at the biggest atom smashers I can find. The best moment was when we discovered the top quark, the heaviest known particle ever discovered. We were all over the newspapers – it was very exciting.

## What has *The Big Bang Theory* done for science?

Enrolment in physics at UCLA has tripled since I came here in the late 90s. If *The Big Bang Theory* shows people there's a good life to be had from a career in science, I think that's a positive outcome. 

**Dr David Saltzberg** is a professor of physics and astronomy at the University of California, Los Angeles. Asteroid 8628 Davidsaltzberg is named after him.

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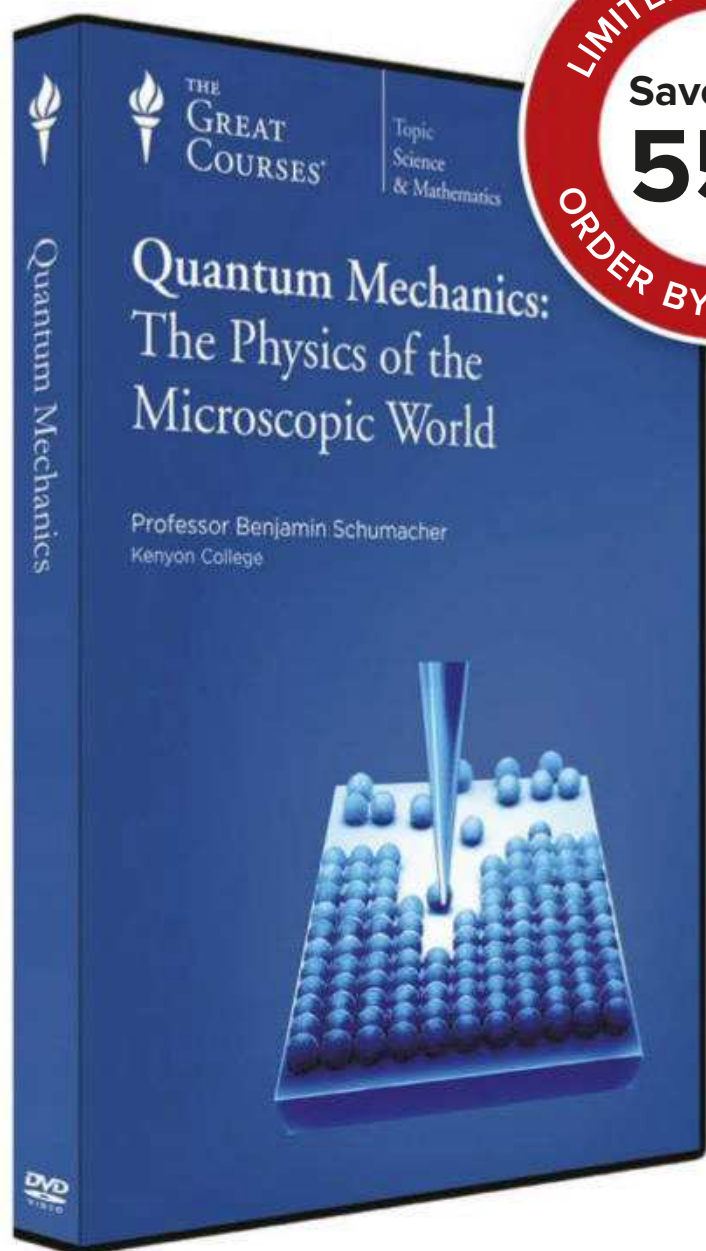
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**"PART OF MY JOB IS TO BE SOMEONE THAT THE WRITERS CAN FORWARD HATE MAIL ON TO!"**





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